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U.S. National Marine Fisheries Service, Galveston, Tex

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16. Abstracts

A dramatic increase in oil exploration and production on the outer continental shelf is projected as the U.S. attempts to reduce its effort to document environmental conditions before, during, and after oil and gas exploration and production. The study described herein deals with the environmental conditions which exist in an oil field surrounded by undeveloped waters. The objectives of the study are: (a) to describe, for an active oil and gas producing field and an unaltered area, the existing ecosystems and the variability in their major components in time and space; and (b) to compare the concentrations of pollutants in the sediments, water and biota in an active field with those in an unaltered area and identify those changes associated with oil and gas exploration and production.

The project utilizes historical and new data to describe and quantify the biological, chemical, and physical characteristics and the temporal variations of these characteristics in the environments of an active field and of an unaltered area. Surveys in the oil field and the unaltered area describe the hydrography, water quality parameters, sediments,

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pollutants, and the abundance, distribution, diversity and habitat of major planktonic, benthic, and pelagic communities. Investigations will determine quantities and rates of movement of pollutants through components of the ecosystems. A separate survey defines the effects of structures themselves on the local ecosystem including community composition and aggregation of species.

Products of this project include a description of changes in a marine environment related to oil and gas exploration and production, and a description of existing environmental conditions.

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA ANNUAL REPORT TO EPA

Environmental Assessment of an Active Oil Field in the Northwestern Gulf of Mexico 1976-1977

A report to the Environmental Protection Agency on work conducted under provisions of the Interagency Agreement EPA-IAG-D5-E-693 during the fiscal years 1976-1977

SOUTHEAST FISHERIES CENTER
GALVESTON LABORATORY

GALVESTON, TEXAS
DECEMBER 1977

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ENVIRONMENTAL ASSESSMENT OF AN ACTIVE OIL FIELD IN THE NORTHWESTERN GULF OF MEXICO, 1976-1977

Project Number
EPA-IAG-D6-E693-EO

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FOREWORD

A dramatic increase in oil exploration and production on the outer continental shelf is projected as the U.S. attempts to reduce its dependency on foreign oil. Supporting this activity is a Federal research effort to document environmental conditions before, during, and after oil and gas exploration and production. The study described herein deals with the environmental conditions which exist in an oil field surrounded by undeveloped waters. The objectives of the study are: (a) to describe, for an active oil and gas producing field and an unaltered area, the existing ecosystems and the variability in their major components in time and space; and (b) to compare the concentrations of pollutants in the sediments, water and biota in an active field with those in an unaltered area and identify those changes associated with oil and gas exploration and production.

The project utilizes historical and new data to describe and quantify the biological, chemical, and physical characteristics and the temporal variations of these characteristics in the environments of an active field and of an unaltered area. Surveys in the oil field and the unaltered area describe the hydrography, water quality parameters, sediments, pollutants, and the abundance, distribution, diversity and habitat of major planktonic, benthic, and pelagic communities. Investigations will determine the quantities and rates of movement of pollutants through components of the ecosystems. A separate survey defines the effects of structures themselves on the local ecosystem including community composition and aggregation of species.

Products of this project include a description of changes in a marine environment related to oil and gas exploration and production, and a description of existing environmental conditions.

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INTRODUCTION

Location of Study Area

The area selected for study is the operational Buccaneer Oil Field located approximately 51.5 kilometers (Km) (32 miles) south by east from Galveston, Texas (Figure 1). This field was selected as the study area because: (a) the field has been in production for about 15 years, which time has allowed full development of the oil-field-associated climax marine communities; (b) it is isolated from other fields which facilitates the selection of an unaltered area (for comparison) within a reasonable distance of the field; (c) it produces both oil and gas that create a major portion of the pollutants from marine mineral extraction; (d) its location simplifies logistics and reduces the cost of the research; and (e) the Texas offshore area has not as yet been fully developed for gas and oil production but will probably experience accelerated exploitation in the near future.

Field Operation History

The Buccaneer oil field was developed by the Shell Oil Company in four blocks of land that were leased in 1960 and 1968 as follows:

Block Number	Acreage	Lease Number	Year
288	2,790	G0709	1960
289	2,610	G1783	1968
295	4,770	G0713	1960
296	4,500	G0714	1960

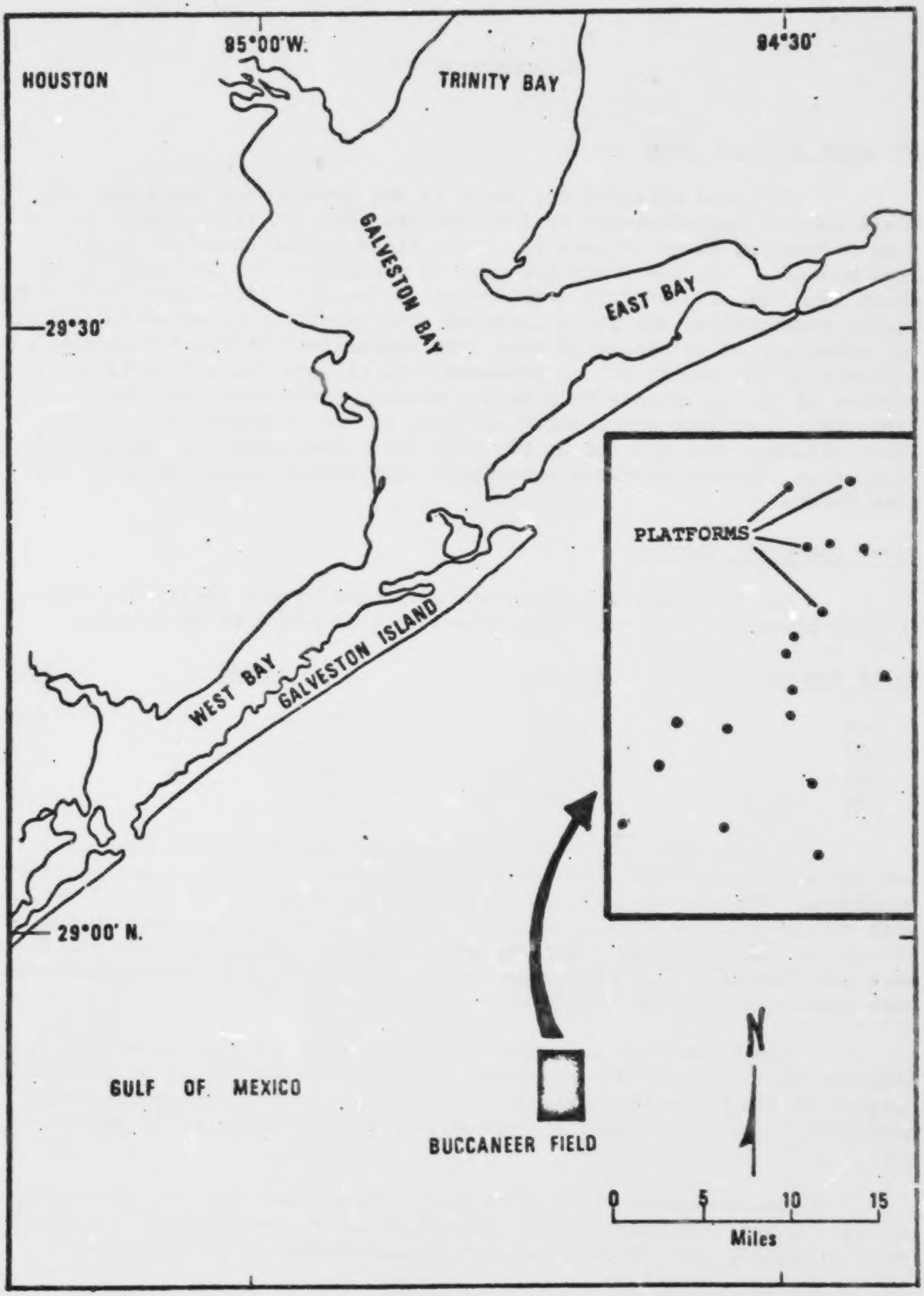
In the development of the field, 18 platforms have been built; two are major platforms, two are auxiliary platforms, and 14 are satellite platforms. Initial exploratory drilling began about mid-summer of 1960 with mobile drilling rigs. When (as the result of the exploratory drilling) the proper locations for platforms were selected, permanent type platforms were constructed. All subsequent drilling and production activities have been conducted from the platforms.

There has been no history of reported oil spills from this field. Although there undoubtedly have been losses of from a barrel of oil upward, because of the mechanical failure of various pieces of equipment, there have been no major oil spills (approaching the magnitude of 50 barrels of oil).

The Buccaneer field first began operations with the production of oil. Later, when significant quantities of gas were found, the field began producing both oil and gas and have continued to do so to date.

Figure 1

Location of Buccaneer Oil Field


95°00'W.
84°30'
HOUSTON
TRINITY BAY
GALVESTON BAY
EAST BAY
29°30'
PLATFORMS
WEST BAY
GALVESTON ISLAND
29°00' N.
GULF OF MEXICO
BUCCANEER FIELD
N
0
5
10
15
Miles

The platforms are connected by a number of pipelines with a 20-inch diameter main pipeline connecting the field to shore. All of the pipelines that are 10 inches or greater in diameter are buried. The Blue Dolphin Pipeline Company was granted a pipeline permit (No. G1381, Blocks 288 and 296) in 1965 and have operated the pipeline since its construction.

The Buccaneer Oil Field occupies a limited area (about 59.3 Km^2) (22.9 sq. miles of leased area) in the western Gulf of Mexico. Because of the geographically small size of this area and because major environmental similarities occur over much of the western Gulf of Mexico, it is anticipated that the results of the proposed studies will be extrapolated to other areas off the Texas coast where oil fields occur or will be developed in the foreseeable future.

ACCESSIBLE DATA BASE MANAGEMENT

Principal Investigator

Francis Mitchell

EXECUTIVE SUMMARY

Data generated from the Buccaneer Oil Field Study must be archived in such a manner that it is easily retrievable for any user group. The objectives of this task are to (1) develop a common format for historical and project-generated data files so that data retrieval, analysis, and documentation are facilitated, and (2) to analyze the historical data base and report gaps to appropriate Principal Investigators and to the Project Manager. For the year, eight Principal Investigators requested 55 data searches and all data formats have been received and are complete.

ACCESSIBLE DATA BASE MANAGEMENT

Bibliographic Literature Searches

Eight Principal Investigators requested 55 searches on the following topics:

- biology of offshore structures
- diet of tropical and subtropical fish
- effects of oil-containing brine effluents on benthic organisms
- ichthyoplankton of the Gulf of Mexico
- trace metals in the Gulf of Mexico
- hydrocarbons in the marine environment
- sulfur effects on the marine environment
- ocean topography
- continental shelf and slope
- paleoclimatology
- coastal erosion
- ocean turbidity
- climatic change
- use of radioisotopes as tracers in soil
- bathymetric mapping
- ocean drilling and core analysis
- ocean sediment: types and properties
- metals and trace elements in seawater

Develop/Adapt Data Formats and Data Archives Processing

A. Preliminary information on data formats sent to Project Officer.

B. Draft data management plan received from Project Officer.

C. Final data formats for BLM/OCS-Southern California received by EDS/NODC and will be offered to this project. This is a sophisticated series of data formats, separated into 17 interdisciplinary levels to accommodate physical, chemical, trace metal, hydrocarbon, sediment and biological data. Its use is being encouraged for all EPA-supported energy-related research as well as its BLM/OCS usage.

D. Two cruise inventory reports (ROSCOP) were received from the Project Office and processed:

1. R/V GUS III, Cruise 5-1, 24-30 May 1976.

   Pelagic eggs/larvae, expendable bathythermograph.

2. R/V GUS III, Cruise 8-2, 16-21 August 1976.

   Pelagic eggs/larvae, expendable bathythermograph.

DATA MANAGEMENT SYSTEM DEVELOPMENT AND MONITORING

Principal Investigators

Hillman Holley
Kenneth Savastano

EXECUTIVE SUMMARY

The goal of the Buccaneer Oil Field Project is to establish and evaluate the effects of active oil fields on marine ecosystems in the northwestern Gulf of Mexico. To make readily available the large amount of data gathered and analyzed, an effective data management system was created with the objectives of ensuring an integrated master project data set and providing a smooth flow of data products from field collectors to analysis and to ultimate users.

Data management activities of the project include:

1. Creation and maintenance of a master data file for all project data.
2. Technical support for developing formats and log forms.
3. Provide Master file data query capability.
4. Maintenance of data transaction and control logs and monthly status reports to the project office.
5. Provide processed data to NOAA's Environmental Data Services (EDS) for archival in the specified format.

Presently, data input formats for every element of the project have been designed, developed and utilized. A control function for handling data transaction and control logs has been implemented and utilized throughout the project. A system for providing master file data query capability has been implemented on the UNIVAC 1108 at the Slidell, Louisiana Computer Complex. Seven of the nine task data files are complete and contain approximately 1,199,000 characters of information. The remaining data should be acquired by June 15, 1977, and the subset data files and master file will be completed. Development of archival data formats and preparation of archival tapes will be completed with delivery of data to EDS in the next three months as scheduled.

In addition, technical interface and coordination with Principal Investigators, EDS, and the project office continues to be provided with respect to all project data management activities.

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ABBREVIATIONS AND SYMBOLS

NFEL	National Fisheries Engineering Laboratory
SEFC	Southeast Fisheries Center
EDS	Environmental Data Service
PI	Principal Investigator
ISRS	Information Storage and Retrieval System

DATA MANAGEMENT PLAN AND CURRENT STATUS FOR ENVIRONMENTAL ASSESSMENT OF AN ACTIVE OIL FIELD IN THE NORTHWESTERN GULF OF MEXICO 1975-1980

1.0 INTRODUCTION

The objective of this report is to outline the basic data management plan and to report on the status of all data management activities during the first year of the project.

The goal of the Buccaneer Oil Field Project is to establish and evaluate the effects of active oil fields on marine ecosystems in the northwest Gulf of Mexico. The design of the project is to compare environmental conditions in an established oil and gas field with those in a similar but unaltered area. The objectives are twofold: (1) describe the existing ecosystems and variabilities in components for an active oil field and an unaltered area, and (2) compare the concentrations of pollutants in the water, sediments, and biota, found in an active oil field with those of an unaltered area and identify those changes associated with oil exploration and production. To make readily available the large amount of data gathered and analyzed, an effective data management system was created with the objectives of ensuring an integrated master project data set and providing a smooth flow of data products from field collectors to analysis and the ultimate users. A data management overview is given in Figure 1.

2.0 DATA FLOW

The general flow of the data is from the Principal Investigators to the Data Manager to the archival center. Principal Investigators will obtain the data from the Data Manager after a master data file has been established. A graphic representation of data flow is given in Figure 2. Non-project data users will have to obtain data from the Environmental Data Service (EDS) after the data have been archived.

All project data will be sent to EDS for final archival. The Data Manager will transmit processed data to EDS in a prescribed format and media. Prior to transmission to EDS, data are available from the Data Manager.

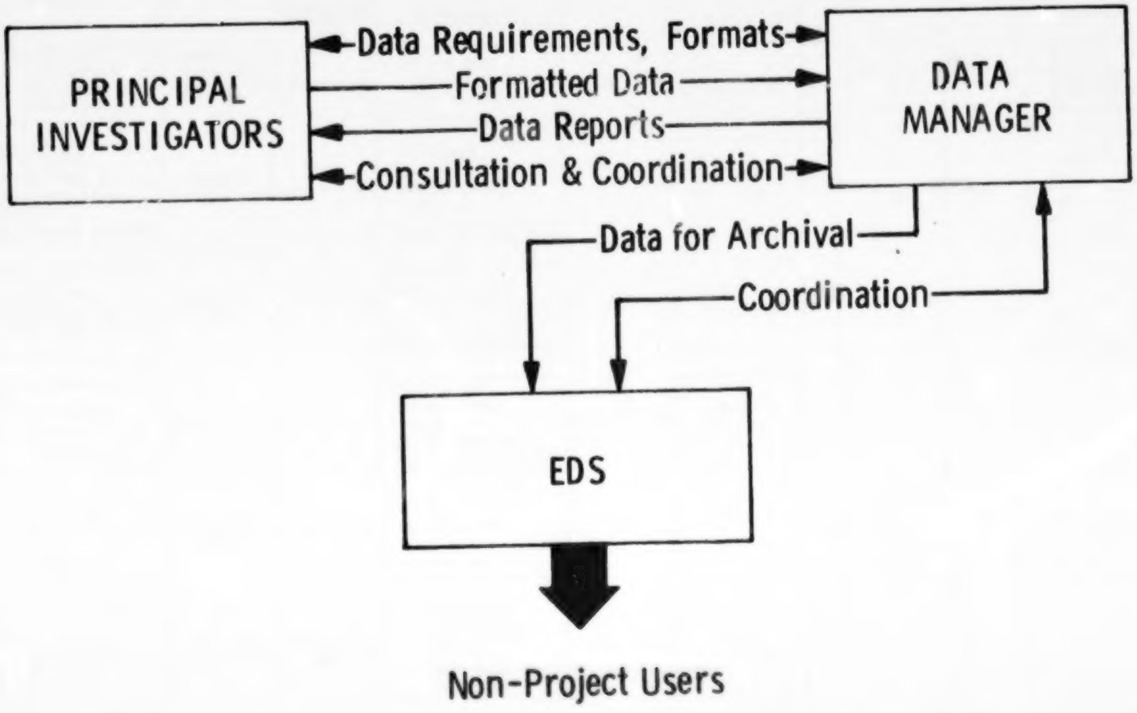

PRINCIPAL INVESTIGATORS
Data Requirements, Formats
Formatted Data
Data Reports
Consultation & Coordination
DATA MANAGER
Data for Archival
Coordination
EDS
Non-Project Users

Figure 1. Data Management Overview

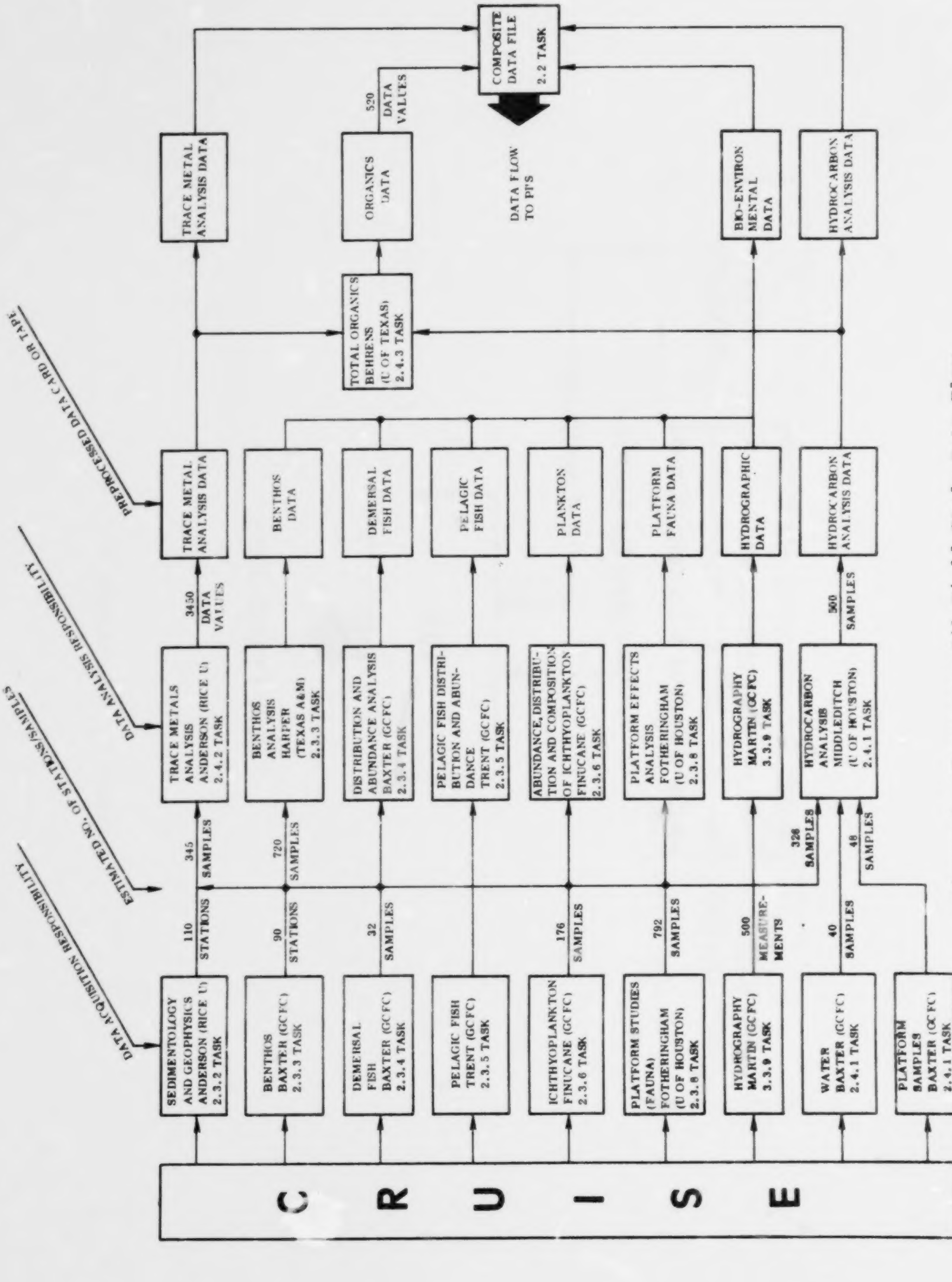

DATA ACQUISITION RESPONSIBILITY
ESTIMATED NO. OF STATIONS/SAMPLES
DATA ANALYSIS RESPONSIBILITY
PREPROCESSED DATA CARD OR TAPE
C R U I S E
SEDIMENTOLOGY AND GEOPHYSICS ANDERSON (RICE U) 2.3.2 TASK
110 STATIONS
345 SAMPLES
TRACE METALS ANALYSIS ANDERSON (RICE U) 2.4.2 TASK
3450 DATA VALUES
TRACE METAL ANALYSIS DATA
TRACE METAL ANALYSIS DATA
BENTHOS BAXTER (GCFC) 2.3.3 TASK
90 STATIONS
720 SAMPLES
BENTHOS ANALYSIS HARPER (TEXAS A&M) 2.3.3 TASK
BENTHOS DATA
DEMERSAL FISH BAXTER (GCFC) 2.3.4 TASK
32 SAMPLES
DISTRIBUTION AND ABUNDANCE ANALYSIS BAXTER (GCFC) 2.3.4 TASK
DEMERSAL FISH DATA
TOTAL ORGANICS BEHRENS (U OF TEXAS) 2.4.3 TASK
ORGANICS DATA
520 DATA VALUES
COMPOSITE DATA FILE 2.2 TASK
DATA FLOW TO PI'S
PELAGIC FISH TRENT (GCFC) 2.3.5 TASK
PELAGIC FISH DISTRIBUTON AND ABUNDANCE TRENT (GCFC) 2.3.5 TASK
PELAGIC FISH DATA
ICHTHYOPLANKTON FINUCANE (GCFC) 2.3.6 TASK
176 SAMPLES
ABUNDANCE, DISTRIBUTION AND COMPOSITION OF ICHTHYOPLANKTON FINUCANE (GCFC) 2.3.6 TASK
PLANKTON DATA
PLATFORM STUDIES (FAUNA) FOTHERINGHAM (U OF HOUSTON) 2.3.8 TASK
792 SAMPLES
PLATFORM EFFECTS ANALYSIS FOTHERINGHAM (U OF HOUSTON) 2.3.8 TASK
PLATFORM FAUNA DATA
HYDROGRAPHY MARTIN (GCFC) 3.3.9 TASK
500 MEASURE- MENTS
HYDROGRAPHY MARTIN (GCFC) 3.3.9 TASK
HYDROGRAPHIC DATA
BIO-ENVIRON MENTAL DATA
WATER BAXTER (GCFC) 2.4.1 TASK
40 SAMPLES
326 SAMPLES
48 SAMPLES
PLATFORM SAMPLES BAXTER (GCFC) 2.4.1 TASK
HYDROCARBON ANALYSIS MIDDLEDITCH (U OF HOUSTON) 2.4.1 TASK
500 SAMPLES
HYDROCARBON ANALYSIS DATA
HYDROCARBON ANALYSIS DATA

Figure 2. Buccaneer Oil Field Study Data Flow

3.0 RESPONSIBILITIES OF PROJECT PARTICIPANTS

The responsibilities of the various project participants, as they apply to the data management requirements, are as follows:

3.1 PROJECT MANAGER

The Project Manager tasks were as follows:

- Ensure that a ROSCOP II is submitted to EDS within 30 days after each data gathering effort and supply a copy to the Data Manager.
- Provide monthly reports to EPA on data management processes.

3.2 PRINCIPAL INVESTIGATORS

The Principal Investigators were responsible for all functions of data collection-processing and analysis. Specifically the principal investigators were responsible for the following:

- Provide data to the Data Manager in mutually acceptable formats and media.
- Contact Data Manager to obtain data from the master data file.

3.3 ENVIRONMENTAL DATA SERVICE

The Environmental Data Service tasks are as follows:

- Provide expertise to the Data Manager as needed in developing formats for all data acquisition.
- Organize and archive all data submitted as a result of project activities into a project data base.
- Serve as the primary distribution point for project-collected data and fulfill requests for data and data products on a reimbursable basis.

3.4 DATA MANAGER

The Data Manager was responsible for developing an efficient data management system and providing for efficient data flow. Specifically the Data Manager tasks were as follows:

- Create and maintain a master data file for all project data.
- Provide technical support for developing formats and log forms.
- Provide a master file data query capability.
- Provide processed data to EDS for archival in the specified format and media along with the required data documentation forms.
- Maintain data transaction and control logs and provide status of data reports to the Project Manager monthly.

4.0 DATA MANAGEMENT SYSTEM

The specific objective of the Data Manager was to design, develop, test and operate a data management system for the Buccaneer Oil Field Project. The development of an efficient data management system was divided into three basic work tasks:

- Task 1 - Project Data Management and EDS Archival Support
- Task 2 - System Development
- Task 3 - Data Base Administration

4.1 PROJECT DATA MANAGEMENT AND EDS ARCHIVAL SUPPORT

4.1.1 Task Workscope - The SEFC/NFEL provides the Project Office an umbrella data management support capability which includes identification of data deliverables and requirements and coordination with the Principal Investigators to identify formats compatible with the EDS data archival requirements. This support includes temporary storage of archival data and actual submittal of the archived data to EDS in their prescribed formats. Data logs and control forms are maintained by NFEL.

4.1.2 Task Status - All Principal Investigators were contacted to identify data deliverables and requirements. This included the definition of data types to be collected, data format and range of data values (including units of measurement). EDS was contacted to supply a copy of all existing data formats. Through discussions with the Principal Investigators and the prior definition of data deliverables and requirements, it was determined that only two EDS formats, presently available, could be used with little or no modifications. The formats will be used in Trace Metals Analysis and are given in Appendix 1 and listed as follows:

- File Type 001 - Metals in Organisms, Sediment and Water
- File Type 021 - Trace Metals

For the remaining data types, loading forms, instruction sheets and formats were designed and printed. Copies of the loading forms and instruction sheets were distributed to the corresponding Principal Investigators. After the initial design and printing, some changes were made to the loading forms and instruction sheets to reflect actual data values and ranges not originally expected. After these changes were made, new loading forms and instruction sheets were printed and redistributed. The final loading forms and instruction sheets are given in Appendix 1.

EDS Archival formats for all data sources (except Trace Metals) are currently being prepared at NFEL. The EDS archival file will be created utilizing the information management system and the master data file upon its completion. The EDS file will be developed and formatted according to formats established with EDS. All the archival data will be writen to magnetic tape and delivered to EDS within the next three months as scheduled. After the establishment of the EDS archival file, all requests for first year project data (other than those made by active project participants) should be made directly to EDS.

In order to control the flow of data and data transaction, a data log and control form was designed, implemented and utilized throughout the project. A data log and control form is shown in Figure 3. The data log and control form along with correspondence with the Principal Investigators were used to provide a monthly status report to the project office.

A list of the data received and their corresponding data logs and control/status of all archival data types transmitted to EDS.

4.2 SYSTEM DEVELOPMENT

4.2.1 Task Workscope - Design and develop a data conversion program to provide input in a specified format to the storage and retrieval portion of the data management system. Utilize an existing storage and retrieval system to provide the necessary capability for storing, adding, changing, deleting, and retrieving operations on the subset data files as well as the master data file. Provide standard print and tape output capabilities for query hit files.

4.2.2 Task Status - The data conversion programs were designed and developed to reformat the data, keypunched at NFEL from loading forms provided by the Principal Investigators, to a new format that is compatible with the data management system's storage and retrieval modules. A data conversion program

DATA LOG AND CONTROL FORM

Task ____________________

Title ____

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT

Figure 3. Data Log and Control Form

has been completed for all later types. The computer segment of the data management system that is being used is the Information Storage and Retrieval System (ISRS). This system is operational on the UNIVAC 1108 at the Slidell Computer Center. System configuration for the UNIVAC 1108 system being utilized is given in Figure 4. A graphic display of the data management software system is given in Figure 5.

Along with each subset and master reformatted data file, a data dictionary is being developed to be utilized in the creation of compressed ISRS data banks. The data dictionary defines each data item and its corresponding range and units of measure. An example of a data dictionary is given in Figure 6.

Key parameters can be defined to decrease access time when retrieving data. The system provides the capability of locating information in the data bank by mathematical calculation, rather than by sequential researching processes. The ISRS has the capability to provide two types of output from queries. The first consists of the subset binary file which can be utilized in further downstream computer analysis programs. The second consists of a query response report. An example of a query response report for all cruises having source items of 50 from the drift/bottle release/recovery data bank is shown in Figure 7.

4.3 DATA BASE ADMINISTRATION

4.3.1 Task Workscope - The primary objective of the Data Base Administration Task is to ensure a fully operational data management system for effective and efficient user access. The Data Manager will provide the following services:

- Manage the data system for support of approved users.
- Maintain data base configuration and integrity.
- Identify, report, and correct deficiencies.
- Modify the data management system to serve changing user needs.
- Provide data base management operations and control procedures for effective data flow.

4.3.2 Task Status - Communication and flow data channels have been established between the Principal Investigators and the Data Manager and also between the Project Manager and the Data Manager. All requests from approved users for data should be made to the Project Manager. This procedure was initiated to

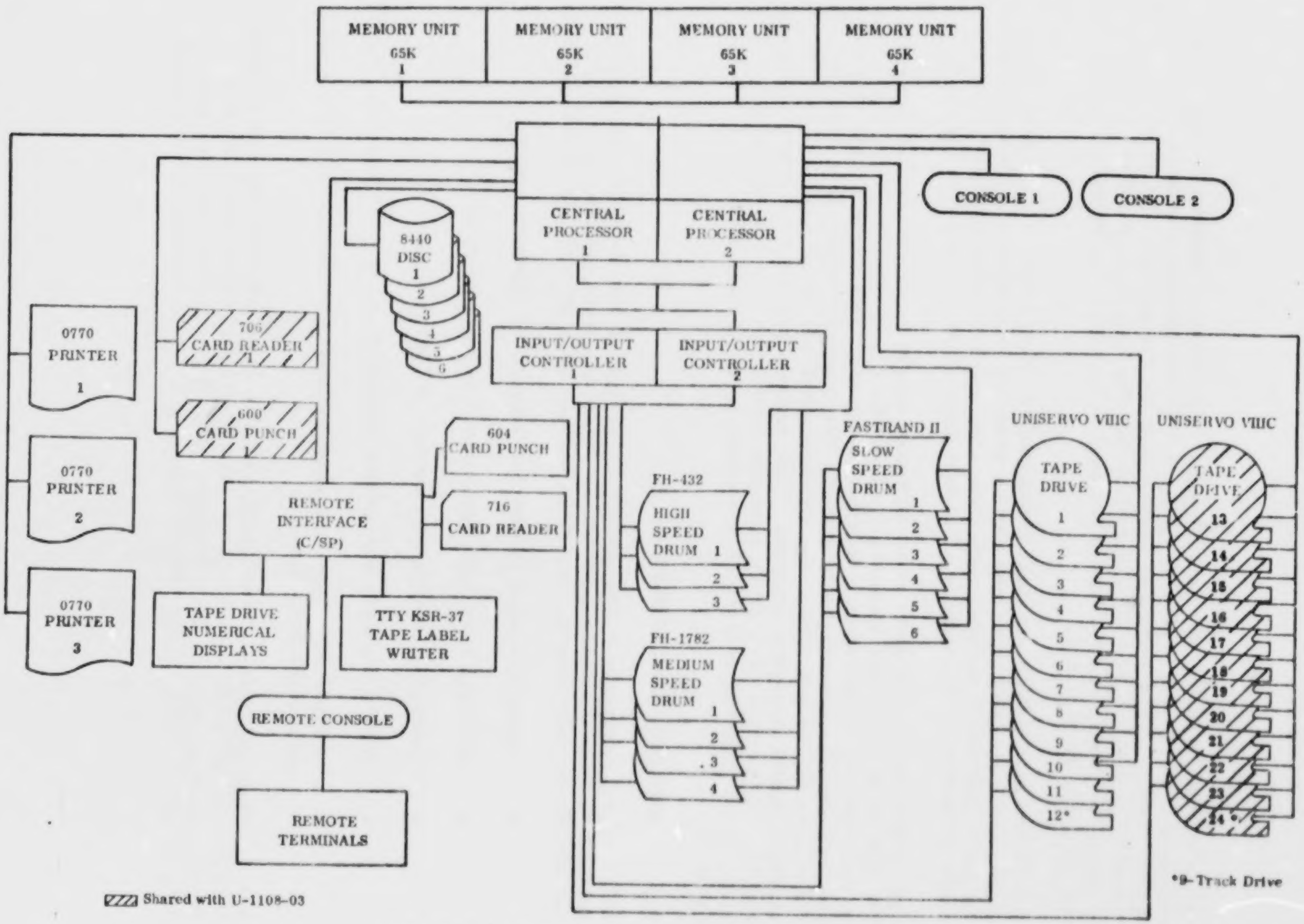

MEMORY UNIT 65K 1
MEMORY UNIT 65K 2
MEMORY UNIT 65K 3
MEMORY UNIT 65K 4
CENTRAL PROCESSOR 1
CENTRAL PROCESSOR 2
CONSOLE 1
CONSOLE 2
INPUT/OUTPUT CONTROLLER 1
INPUT/OUTPUT CONTROLLER 2
8440 DISC 1 2 3 4 5 6
0770 PRINTER 1
0770 PRINTER 2
0770 PRINTER 3
706 CARD READER
600 CARD PUNCH
604 CARD PUNCH
716 CARD READER
REMOTE INTERFACE (C/SP)
TAPE DRIVE NUMERICAL DISPLAYS
TTY KSR-37 TAPE LABEL WRITER
REMOTE CONSOLE
REMOTE TERMINALS
FH-432
HIGH SPEED DRUM 1 2 3
FH-1782
MEDIUM SPEED DRUM 1 2 3 4
FASTRAND II
SLOW SPEED DRUM 1 2 3 4 5 6
UNISERVO VIIIC
TAPE DRIVE 1 2 3 4 5 6 7 8 9 10 11 12*
UNISERVO VIIIC
TAPE DRIVE 13 14 15 16 17 18 19 20 21 22 23 24*
▨ Shared with U-1108-03
*9-Track Drive

Figure 4. UNIVAC 1108 Multiprocessor (1108-01)

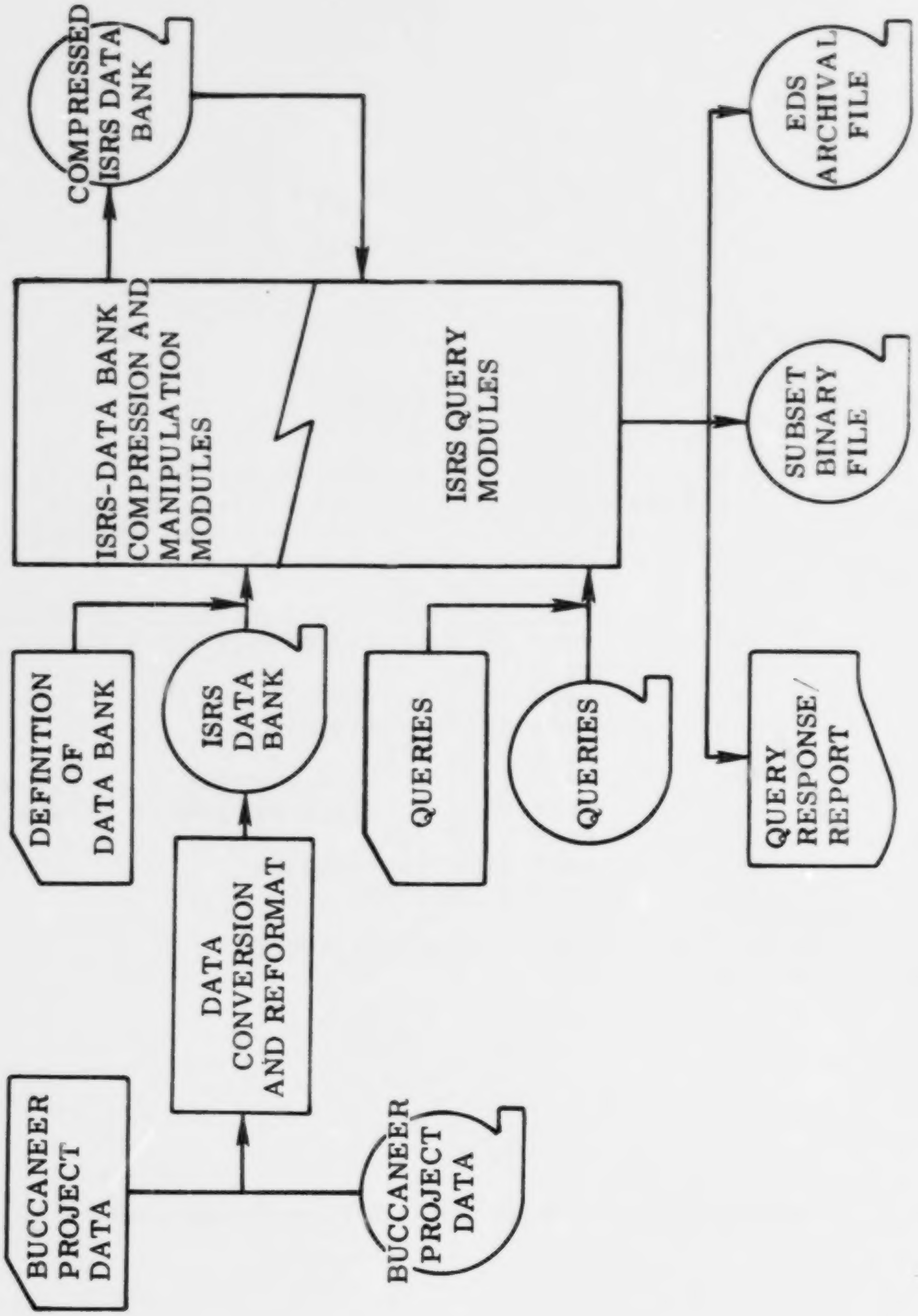
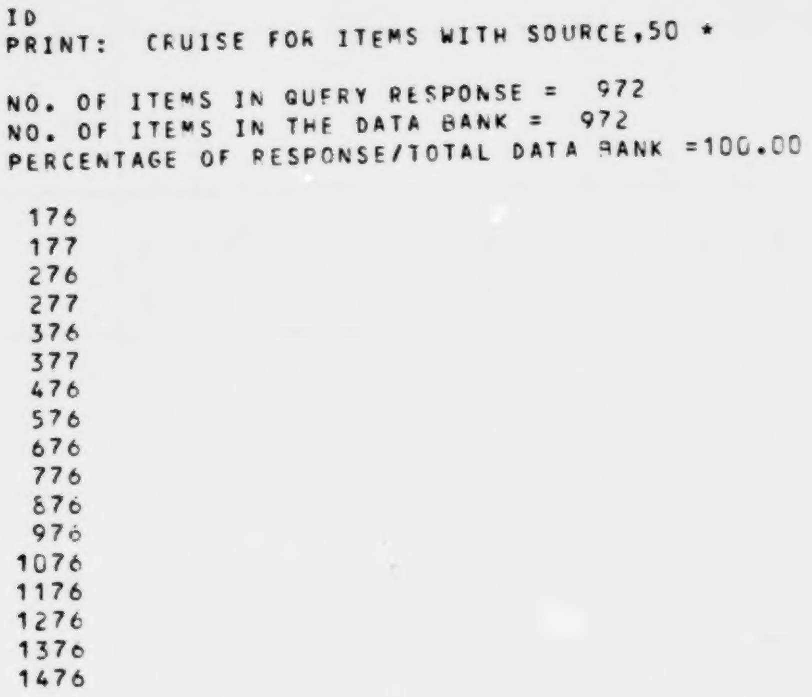

BUCCANEER PROJECT DATA
BUCCANEER PROJECT DATA
DATA CONVERSION AND REFORMAT
DEFINITION OF DATA BANK
ISRS DATA BANK
QUERIES
QUERIES
ISRS-DATA BANK COMPRESSION AND MANIPULATION MODULES
ISRS QUERY MODULES
COMPRESSED ISRS DATA BANK
QUERY RESPONSE/ REPORT
SUBSET BINARY FILE
EDS ARCHIVAL FILE

Figure 5. Data Management Software System

```
ID
SELECT DESCRIPTORS 90
BALLAST              ( 1 CODE NO,YES),
BOTTLE NO.           ( 2         FROM 1 TO 99999),
CRUISE               ( 3         FROM 1 TO 9999),
DAYS OUT             ( 4         FROM 1 TO 999),
DISTANCE             ( 5         FROM 1 TO 99999 DECIMAL 1 IN KM.),
LOCATION             ( 6 CODE NORTH WEST GULF OF MEXICO,UNKNOWN),
RATE                 ( 7         FROM 0 TO 999 DECIMAL 1 IN KM/DAY),
REC. DATE            ( 8         FROM 10176 TO 123199),
REC. DAY             ( 9         FROM 1 TO 31),
REC. LAT             (10         FROM 1800 TO 3100 DECIMAL 2 IN DEG.N.),
REC. LON             (11         FROM 8000 TO 11000 DECIMAL 2 IN DEG.W.),
REC. MONTH           (12         FROM 1 TO 12),
REC. YEAR            (13         FROM 1976 TO 1999),
REL. DATE            (14         FROM 10176 TO 123199),
REL. DAY             (15         FROM 1 TO 31),
REL. LAT             (16         FROM 2400 TO 3100 DECIMAL 2 IN DEG.N.),
REL. LON             (17         FROM 8000 TO 11000 DECIMAL 2 IN DEG.W.),
REL. MONTH           (18         FROM 1 TO 12),
REL. YEAR            (19         FROM 1976 TO 1999),
SOURCE               (20         FROM 0 TO 99)*
ADJUST DESCRIPTORS
1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20*
COMPILE ITEMS FROM TAPE
```

Figure 6. Data Dictionary for Drift Bottle Release/Recovery Data Bank



```
ID
PRINT:  CRUISE FOR ITEMS WITH SOURCE,50 *

NO. OF ITEMS IN QUERY RESPONSE =  972
NO. OF ITEMS IN THE DATA BANK =  972
PERCENTAGE OF RESPONSE/TOTAL DATA BANK =100.00

 176
 177
 276
 277
 376
 377
 476
 576
 676
 776
 876
 976
1076
1176
1276
1376
1476
```

Figure 7. Query Response Report From Release/Recovery Data Bank

allow the project office to maintain control over data dissemination. The data received from the Principal Investigators are presently being incorporated into the ISRS Data Banks. The status of data incorporated into the data management system by Task is shown in Figure 8.

PROGRAM TASK	LOAD FORM FORMAT CONTENT % Complete	LOAD FORM DESIGN % Complete	FINAL FORMS PRODUCED % Complete	DATA CONVERSION PROGRAM % Complete	SUBSET DATA FILE % Complete	* -1 File Size	EDS FORMAT % Complete	* -2 Archival
Task 2.3.3 **Benthos**	100	100	100	100				
Task 2.3.4 **Demersal Fish**	100	100	100	100		400,000		
Task 2.3.5 **Pelagic Fish**	100	100	100	100		30,000		
Task 2.3.6 Ichthyoplankton	100	100	100	100		120,000		
Task 2.3.8 **Platform Studies**								
.Bird Data	100	100	100	100	100	57,000		
.Plankton	100	100	100	100		36,000		
.Fish Determination	100	100	100	100		500		
.Fish & Macro-Invertebrate Quadrants	100	100	100	100		500		
.Sessile Fauna Quadrant	100	100	100	100		131,000		
Task 2.3.9 **Hydrography**								
.Drift Bottle Release/ Recovery	100	100	100	100	100	85,000		
.Environmental	100	100	100	100		140,000		
Task 2.4.1 Hydrocarbons	100	100	100	100		300,000		
Task 2.4.2 Trace Metals	100	100	100	100			100	
Task 2.4.3 Total Organics	100	100	100	100		30,000		

* -1 File Size in Characters   * -2 Data to be Archived Within 3 Months

Figure 8. Status of Data Incorporated into Data Management System

APPENDIX 1

FINISHED FORMATS

APPENDIX 1

FINISHED FORMAT

TASK	LOAD FORM TITLE
2.3.4	EPA Fauna Survey
2.3.6	EPA Ichthyoplankton Survey Loading Form
2.3.8	Bird Data Format
2.3.8	Plankton Samples
2.3.8	Fish Determination
2.3.8	Fish and Macro-Invertebrate Quadrants
2.3.8	Sessile Fauna Quadrant
2.3.9	Drift Bottle Release/Recovery Log
2.4.1	Hydrocarbons
2.4.2	Trace Metals in Water, Organisms and Sediments
2.4.3	Total Organics

EPA FAUNA SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"57" (constant)
Card Type	3	1	I1	"1" (constant)
Date	4	6	3I2	Month, day, year
Station Number	10	3	A3	Station Number
Latitude	13	6	3I2	Degrees, minutes, seconds
Longitude	19	6	3I2	Degrees, minutes, seconds
Start Time	25	4	I4	Time - 24 hour clock
Durating Time	29	4	2I2	Duration in hours and minutes
Sample Depth	33	4	F4.1	Sample depth in meters to tenths
Gear Type	37	2	I2	Gear Type = 1 Trawling = 4 Trolling = 2 Trapping = 5 Gillnetting = 3 Longlining
Gear Code	39	2	I2	Trapping = 1 Bottom Trap = 2 Floating Trap
Vessel Speed	41	2	I2	Vessel speed in knots
Total Number Caught	43	4	I4	Total number of individuals caught
Total Weight	47	8	F8.1	Weight of catch in kilograms to tenths
Number of Species	55	3	I3	Number of different species in catch
Subsample Weight	58	7	F7.1	Weight in subsample in kilograms to tenths

EPA FAUNA SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"57" (constant)
Card Type	3	1	I1	"2" (constant)
Date	4	6	3I2	Month, day, year
Station Number	10	3	A3	Station Number - (same as on Type 1 card)
Species Sample Number	13	3	I3	Sample number of species
Species	16	10	A6A4	Species identification
Gear Type	26	1	I1	Gear Type (same as Type 1 card)
Gear Code	27	1	I1	Gear Code (same as on Type 1 card)
Species Weight	28	5	F5.1	Total weight of individuals in sample of specified species in grams to tenths
MEASURED INDIVIDUALS				
Length	33	5	F5.0	Length of measured individuals in millimeters
Weight	38	5	F5.1	Weight of measured individual in grams to tenths
NOTE: A minus sign in First column of weight field indicates weight in kilograms instead of grams. Up to three additional length/weight measurements can be entered on this card.				
Number in Sample	73	4	I4	Total number of individuals in sample of specified species

EPA FAUNA SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"57" (constant)
Card Type	3	1	I1	"3" (constant)
Date	4	6	3I2	Month, day, year
Station Number	10	3	A3	Station Number (same as on Type 1 card)
Species Sample Number	13	3	I3	Sample Number of Species (Same as on Type 2 card)
MEASURED INDIVIDUALS				
Length	16	5	F5.0	*Length of measured individual in millimeters
Weight	21	5	F5.1	Weight of measured individual in grams to tenths
NOTE: A minus sign in first column of weight field indicates weight in kilograms instead of grams. Up to five additional length/weight measurements can be entered on this card) *As many Type 3 cards can be used as necessary to complete length/weight measurements.				
Gear Type	76	1	I1	Gear Type (Same as on Type 1 card)
Gear Code	77	1	I1	Gear Code (Same as on Type 1 card)

EPA FAUNA SURVEY

DATA SOURCE CODE	CARD TYPE	DATE			STATION NUMBER	LATITUDE			LONGITUDE			TIME				SAMPLE DEPTH (M)	GEAR TYPE	GEAR CODE	VESSEL SPEED (KNOTS)	TOTAL NUMBER CAUGHT	TOTAL WEIGHT (KG)	NUMBER OF DIFFERENT SPECIES	SUBSAMPLE WEIGHT (KG)	
												START		DURATION										
		MO	DAY	YR		DEG	MIN	SEC	DEG	MIN	SEC	HR	MIN	HR	MIN									
1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34 35 36	37 38	39 40	41 42	43 44 45 46	47 48 49 50 51 52 53 54	55 56 57	58 59 60 61 62 63 64	65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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EPA FAUNA SURVEY

DATA SOURCE CODE	CARD TYPE	DATE			STATION NUMBER	SPECIES SAMPLE NUMBER	SPECIES	GEAR TYPE	GEAR CODE	SPECIES WEIGHT	MEASURED INDIVIDUALS								NUMBER IN SAMPLE	
		MO	DAY	YR							LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)		
1 2	3	4 5	6 7	8 9	10 11 12	13 14 15	16 17 18 19 20 21 22 23 24 25	26	27	28 29 30 31 32	33 34 35 36 37	38 39 40 41 42	43 44 45 46 47	48 49 50 51 52	53 54 55 56 57	58 59 60 61 62	63 64 65 66 67	68 69 70 71 72	73 74 75 76	77 78 79 80
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EPA FAUNA SURVEY

DATA SOURCE CODE	CARD TYPE	DATE MO	DATE DAY	DATE YR	STATION NUMBER	SPECIES SAMPLE NUMBER	MEASURED INDIVIDUALS LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)	LENGTH (MM)	WEIGHT (GMS)	GEAR TYPE	GEAR CODE	
1 2	3	4 5	6 7	8 9	10 11 12	13 14 15	16 17 18 19 20	21 22 23 24 25	26 27 28 29 30	31 32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48 49 50	51 52 53 54 55	56 57 58 59 60	61 62 63 64 65	66 67 68 69 70	71 72 73 74 75	76	77	78 79 80
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EPA ICHTHYOPLANKTON SURVEY LOAD FORM

DATA SOURCE CODE	GEAR TYPE CODE	CARD TYPE CODE	CRUISE NUMBER	DATE			LOCATION						TIME				SPECIES	NUMBER OF SPECIMENS	MIN SIZE	MAX SIZE	MEAN SIZE	DISPLACEMENT VOLUME	WATER FILTERED	NUMBER OF EGGS	
							LATITUDE			LONGITUDE			START		DURATION										
				DA	MO	YR	°	'	"	°	'	"	HR	MIN	MIN	SEC									

EPA ICHTHYOPLANKTON SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"2" (constant)
Gear Type	3	2	I2	Collection gear = 1 Neuston Net = 2 Bongo Net, 333 μ Mesh = 3 Bongo Net, 505 μ Mesh
Cruise Number	6	2	I2	Cruise Number
Date	8	6	3I2	Day, month, year
Latitude	14	6	3I2	Latitude of sample in degrees, minutes and seconds
Longitude	20	6	3I2	Longitude of sample in degrees, minutes and seconds
Start Time	26	4	I4	24 hour clock
Duration	30	4	2I2	Length of time of tow in minutes and seconds
Species	34	9	I9	Bionumeric code of species
Number of Species	44	4	I4	Number of individuals caught
Minimum Size	48	4	F4.1	Size of smallest individual in millimeters to tehtns
Maximum Size	52	4	F4.1	Size of largest individual in millimeters to tenths
Mean Size	56	4	F4.1	Mean size in millimeters to tenths
Displacement Volume	60	4	F4.1	Displacement volume of plankton sample in millimeters to tenths
Water Filtered	64	4	F4.1	Volume of water filtered during the tow to tenths of a M^3
Number of Eggs	68	5	I4	Number of fish eggs in sample

BIRD DATA FORMAT

Field Name	Position	Length	Format	Use and Meaning
File Type	1	1	I1	"5" (constant)
Date	2	6	3I2	Month, day, year
Location	8	1	A1	P= Platform C = Control area
Species	9	24	4A6	Species Name 4 in column 9 indicated unidentified species
Time Interval 0600 - 0959				
Dead	33	2	I2	Number dead
Captured	35	2	I2	Number captured
Platform	37	2	I2	Number on platform
Flying - Number	39	4	I4	Number flying
Flying - Direction	43	2	A2	Direction
Time Interval 1000 - 1359				
Dead	45	2	I2	Number dead
Captured	47	2	I2	Number captured
Platform	49	2	I2	Number on platform
Flying - Number	51	4	I4	Number flying
Flying - Direction	55	2	A2	Direction
Time Interval 1400 - 1759				
Dead	57	2	I2	Number dead
Captured	59	2	I2	Number captured
Platform	61	2	I2	Number on platform
Flying - Number	63	4	I4	Number flying
Flying - Direction	67	2	A2	Direction
Time Interval 1800 - 2159				
Dead	69	2	I2	Number dead
Captured	71	2	I2	Number captured
Platform	73	2	I2	Number on platform

BIRD DATA FORMAT

Field Name	Position	Length	Format	Use and Meaning
Flying - Number	75	4	I4	Number flying
Flying - Direction	79	2	A2	Direction

BIRD DATA FORMAT

FILE TYPE	DATE			LOCATION	SPECIES	TIME INTERVAL 0600-0959					TIME INTERVAL 1000-1359					TIME INTERVAL 1400-1759					TIME INTERVAL 1800-2159				
						DEAD	CAPTURED	PLATFORM	FLYING		DEAD	CAPTURED	PLATFORM	FLYING		DEAD	CAPTURED	PLATFORM	FLYING		DEAD	CAPTURED	PLATFORM	FLYING	
	Mo	Day	Yr						Number	Dir.				Number	Dir.				Number	Dir.				Number	Dir.
1	2 3	4 5	6 7	8	9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	33 34	35 36	37 38	39 40 41 42	43 44	45 46	47 48	49 50	51 52 53 54	55 56	57 58	59 60	61 62	63 64 65 66	67 68	69 70	71 72	73 74	75 76 77 78	79 80
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PLANKTON SAMPLES

Field Name	Position	Length	Format	Use and Meaning
File Type	1	1	I1	"9" (constant)
Card Type	2	1	I1	"1" (constant)
Station	3	5	A5	Station Number
Date	8	6	3I2	Month, day, year
Mesh Size	14	3	I3	Mesh Size = 243 or 80
Sample Number	17	2	I2	Sample Number
Sample Time	19	4	I4	24 Hour Clock
Volume of water sampled	23	6	F6.1	Volume of water sampled in tenths of M^3
Subsample Size	29	3	I3	Percentage of total sample to nearest percent
Estimated density of Holoplankton	32	8	F8.1	Estimated density per M^3 to tenths
Estimated density of Meroplankton	40	8	F8.1	Estimated density per M^3 to tenths
Proportion of Meroplankton	48	6	F6.4	Proportion to ten thousandths
File Type	1	1	I1	"9" (constant)
Card Type	2	1	I1	"2" (constant)
Station	3	5	A5	Station Number
Date	8	6	3I2	Month, day, year
Mesh Size	14	1	I1	Mesh Size "0" (constant)
Sample Number	15	2	I2	Sample Number
Sample Time	17	4	I4	24 Hour Clock
Volume Sampled	21	7	F7.5	Volume of Water Sampled to hundred thousandths
Subsample Size	28	3	I3	Percentage of total sample to nearest percent
Estimated density of Holoplankton	31 39	5 2	F5.2 I2	Estimated density/M^3 in scientific notation with exponent in Column 39 and 40

PLANKTON SAMPLES (Cont'd)

Field Name	Position	Length	Format	Use and Meaning
Estimated density of Meroplankton	41 49	5 2	F7.0 I2	Estimated density/M^3 in scientific notation with exponent in Column 49 and 50
Proportion of Meroplankton	51	6	F6.4	Proportion to ten thousandths

PLANKTON SAMPLES

FILE TYPE	CARD TYPE	STATION	DATE MO	DATE DAY	DATE YR	MESH SIZE	SAMPLE NUMBER	SAMPLE TIME	VOLUME SAMPLED (M3)	SUBSAMPLE SIZE (%)	ESTIMATED DENSITY (/M3) HOLOPLANKTON	ESTIMATED DENSITY (/M3) MEROPLANKTON	PROPORTION OF MEROPLANKTON	
1	2	3 4 5 6 7	8 9	10 11	12 13	14 15 16	17 18	19 20 21 22	23 24 25 26 27 28	29 30 31	32 33 34 35 36 37 38 39	40 41 42 43 44 45 46 47	48 49 50 51 52 53	54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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PLANKTON SAMPLES

FILE TYPE	CARD TYPE	STATION	DATE			MESH SIZE	SAMPLE NUMBER	SAMPLE TIME	VOLUME SAMPLED (M3)	SUBSAMPLE SIZE (%)	ESTIMATED DENSITY (M3)		PROPORTION OF MEROPLANKTON	
			MO	DAY	YR						HOLOPLANKTON	MEROPLANKTON		
9	2					0			.		. 10	. 10	.	
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9	2					0			.		. 10	. 10	.	

FISH DETERMINATION

Field Name	Position	Length	Format	Use and Meaning
File Type	1	1	I1	"8" (constant)
Record Type	2	1	I1	"1" (constant)
Station	3	5	A5	Station Number
Date	8	6	3I2	Month, day, year
Species Sequence	14	3	I3	Sequence number of species sheets per station for each date
Species	17	30	5A6	Species name
Number	47	3	I3	Individual Number
Length	50	3	F3.1	Length in centimeters to tenths
Wet Weight	53	4	F4.0	Weight in grams
Sex	57	1	A1	M = Male F = Female blank = Unknown
Age	58	2	I2	Age to nearest year
Determined from	60	1	I1	1 = Otolith 2 = Scales 3 = Spines 4 = Markings
Ovigerous	61	1	I1	1 = Yes 0 = No
Number	62	3	I3	Individual Number
Length	65	3	F3.1	Length in centimeters to tenths
Wet Weight	68	4	F4.0	Weight in grams
Sex	72	1	A1	M = Male F = Female blank = Unknown
Age	73	2	I2	Age to nearest year
Determined from	75	1	I1	1 = Otolith 2 = Scales 3 = Spines 4 = Markings

FISH DETERMINATION

Field Name	Position	Length	Format	Use and Meaning
Ovigerous	76	1	I1	1 = Yes 0 = No
File Type	1	1	I1	"8" constant
Record Type	2	1	I1	"2" constant
Station	3	5	A5	Station Number
Date	8	6	3I2	Month, day, year
Species Sequence	14	3	I3	Sequence number of species sheets per station for each date
Number	17	3	I3	Individual number
Length	20	3	F3.1	Length in centimeters to tenths
Wet Weight	23	4	F4.0	Weight in grams
Sex	27	1	A1	M = Male F = Female blank - Unknown
Age	28	2	I2	Age to nearest year
Determined from	30	1	I1	1 = Otolith 2 = Scales 3 = Spines 4 = Markings
Ovigerous	31	1	I1	1 = Yes 0 = No

NOTE: Up to four different individuals can be put on each type "2" card.

FISH DETERMINATION

FILE TYPE	RECORD TYPE	STATION	DATE			SPECIES SEQUENCE	SPECIES	NUMBER	LENGTH (CM)	WET WEIGHT (GM)	SEX	AGE	DETERMINED FROM	OVIGEROUS	NUMBER	LENGTH (CM)	WET WEIGHT (GM)	SEX	AGE	DETERMINED FROM	OVIGEROUS	
			Mo	Day	Yr																	
1	2	3 4 5 6 7	8 9	10 11	12 13	14 15 16	17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	47 48 49	50 51 52	53 54 55 56	57	58 59	60	61	62 63 64	65 66 67	68 69 70 71	72	73 74	75	76	77 78 79 80
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FISH DETERMINATION

FILE TYPE	RECORD TYPE	STATION	DATE			SPECIES SEQUENCE	NUMBER	LENGTH (CM)	WET WEIGHT (GM)	SEX	AGE	DETERMINED FROM	OVIGEROUS	NUMBER	LENGTH (CM)	WET WEIGHT (GM)	SEX	AGE	DETERMINED FROM	OVIGEROUS	NUMBER	LENGTH (CM)	WET WEIGHT (GM)	SEX	AGE	DETERMINED FROM	OVIGEROUS	NUMBER	LENGTH (CM)	WET WEIGHT (GM)	SEX	AGE	DETERMINED FROM	OVIGEROUS	
			Mo	Day	Yr																														
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FISH AND MACRO INVERTEBRATE QUADRATS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	1	I1	"7" (constant)
Record Type	2	1	I1	"1" (constant)
Station	3	5	A5	Station Number
Date	8	6	3I2	Month, day, year
Time	14	4	I4	24 Hour Clock
Pelagic Quadrat Depth	18	3	F3.1	Pelagic quadrat depth in meters to tenths
Sequence Number	21	3	I3	Sequence Number
Taxon	24	24	4A6	Species Name
Density	48	3	F3.1	Density to tenths
Sequence Number	51	3	I3	Sequence Number
Taxon	54	24	4A6	Species Name
Density	78	3	F3.1	Density to tenths
File Type	1	1	I1	"7" (constant)
Record Type	2	1	I1	"2" (constant)
Station	3	5	A5	Station Number
Date	8	6	3I2	Month, day, year
Time	14	4	I4	24 Hour Clock
Benthic Quadrat	18	3	F3.1	Fishrake = 300 Circular = 785
Sequence Number	21	3	I3	Sequence Number
Taxon	24	24	4A6	Species Name
Density	48	3	F3.1	Density to tenths
Sequence Number	51	3	I3	Sequence Number
Taxon	54	24	4A6	Species Name
Density	78	3	F3.1	Density to tenths

FISH AND MACRO-INVERTEBRATE QUADRATS

FILE TYPE	RECORD TYPE	STATION	DATE Mo	DATE Day	DATE Yr	TIME (24 HOUR CLOCK)	PELAGIC QUADRAT DEPTH (M) ●	SEQUENCE NUMBER	TAXON	DENSITY ●	SEQUENCE NUMBER	TAXON	DENSITY ●
1	2	3 4 5 6 7	8 9	10 11	12 13	14 15 16 17	18 19 20	21 22 23	24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	48 49 50	51 52 53	54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77	78 79 80
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FISH AND MACRO-INVERTEBRATE QUADRATS

FILE TYPE	RECORD TYPE	STATION	DATE Mo	DATE Day	DATE Yr	TIME (24 HOUR CLOCK)	BENTHIC QUADRAT (M2) ●	SEQUENCE NUMBER	TAXON	DENSITY ●	SEQUENCE NUMBER	TAXON	DENSITY ●
1	2	3 4 5 6 7	8 9	10 11	12 13	14 15 16 17	18 19 20	21 22 23	24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	48 49 50	51 52 53	54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77	78 79 80
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SESSILE FAUNA QUADRAT
(Photogrammetric Results)

Field Name	Position	Length	Format	Use and Meaning
File Type	1	1	I1	"6" (constant)
Record Type	2	1	I1	"1" (constant)
Date	3	6	3I2	Month, day, year
Station	9	5	A5	Station Number
Leg	14	2	I2	
Depth	16	3	F3.1	Depth in meters to tenths
Quadrat	19	3	F3.1	Quadrat in square meters to tenths
Treatment	22	1	I1	1 = Scraped 2 = Covered
Date Initiated	23	6	3I2	Month, day, year
Sequence	29	2	I2	Species sequence number
Species	31	24	4A6	Species name
Number	55	3	I3	Number of individuals or colonies
Recruits	58	2	I2	Number of recruits
Deaths	60	2	I2	Number of deaths
Percent Cover	62	4	F4.1	Percent cover to tenths
Measured	66	1	I1	1 = Area 2 = Greatest diameter 3 = Other blank = No measurement
Measurement	67	3	F3.1	To tenths
Measurement	70	3	F3.1	To tenths
NOTE: There can be up to 2 additional measurements on this card				
File Type	1	1	I1	"6" (constant)
Record Type	2	1	I1	"2" (constant)
Date	3	6	3I2	Month, day, year
Station	9	5	A5	Station Number
Leg	14	2	I2	
Sequence	16	2	I2	Species sequence number

SESSILE FAUNA QUADRAT
(Photogrammetric Results)

Field Name	Position	Length	Format	Use and Meaning
Species	18	24	4A6	Species name
Number	42	3	I3	Number of individuals or colonies
Recruits	45	2	I2	Number of recruits
Deaths	47	2	I2	Number of deaths
Percent Cover	49	4	F4.1	Percent cover to tenths
Measured	53	1	I1	1 = Area 2 = Greatest diameter 3 = Other blank = No measurement
Measurement	54	3	F3.1	To tenths
Measurement	57	3	F3.1	To tenths
NOTE: There can be up to 7 additional measurements on this card				
File Type	1	1	I1	"6" (constant)
Record Type	2	1	I1	"3" (constant)
Date	3	6	3I2	Month, day, year
Station	9	5	A5	Station Number
Leg	14	2	I2	
Sequence	16	2	I2	Species sequence number
Measurement	18	3	F3.1	To tenths
Measurement	21	3	F3.1	To tenths
NOTE: There can be up to 19 additional measurements on this card				

SESSILE FAUNA QUADRAT (PHOTOGRAMMETRIC RESULTS)

FILE TYPE	RECORD TYPE	DATE Mo.	DATE Day	DATE Yr	STATION	LEG	DEPTH (M)	QUADRAT (M2)	TREATMENT	DATE INITIATED Mo.	DATE INITIATED Day	DATE INITIATED Yr	SEQUENCE	SPECIES	NUMBER	RECRUITS	DEATHS	PERCENT COVER	MEASURED	MEASUREMENT	MEASUREMENT	MEASUREMENT	MEASUREMENT	
1	2	3–4	5–6	7–8	9–13	14–15	16–18	19–21	22	23–24	25–26	27–28	29–30	31–54	55–57	58–59	60–61	62–65	66	67–69	70–72	73–75	76–78	79–80
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SESSILE FAUNA QUADRAT (PHOTOGRAMMETRIC RESULTS)

FILE TYPE	RECORD TYPE	DATE Mo	DATE Day	DATE Yr	STATION	LEG	DEPTH (M) •	QUADRAT (M^2) •	SEQUENCE	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •	MEASUREMENT •
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DRIFT BOTTLE RELEASE/RECOVERY LOG

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	"50" (constant)
Card Type	3	1	I1	"1" (constant)
Cruise Number	4	4	I4	Cruise Number
Bottle Number	8	5	I4	Bottle Number
Ballast	13	1	A1	Ballast
RELEASE DATA				
Date	14	6	3I2	Year, month and day of release
Latitude	20	6	I2, F4.1	Latitude of release in degrees and minutes to tenths of a minute
Longitude	26	6	I2, F4.1	Longitude of release in degrees and minutes to tenths of a minute
RECOVERY DATA				
Date	32	6	3I2	Year, number and day of recovery
Latitude	38	6	I2, F4.1	Latitude of recovery in degrees and minutes to tenths of a minute
Longitude	44	6	I2, F4.1	Longitude of recovery in degrees and minutes to tenths of a minute
Day Out	50	3	I3	Number of days out
Distance	53	6	F6.1	Distance traveled in kilometers to tenths
Rate	59	4	F4.1	Rate in kilometers/day to tenths
Location	63	5	3A, A2	Location of work Col 63 = N = North 64 = W = West 65 = G = Gulf 66, 67 = MX = Mexico

DRIFT BOTTLE RELEASE RECOVERY LOG

FILE TYPE	CARD TYPE	CRUISE NUMBER	BOTTLE DATA		RELEASE DATA							RECOVERY DATA							DAYS OUT	DISTANCE (Km)	RATE (Km-DAY)	LOCATION OF WORK	
			BOTTLE NO.	BALLAST	DATE			LATITUDE		LONGITUDE		DATE			LATITUDE		LONGITUDE						
					YR	MO.	DA.	DEG	MIN	DEG	MIN	YR	MO.	DA.	DEG	MIN	DEG	MIN					
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HYDROCARBONS

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"62" (Constant)
Card Type	3	1	I1	"1" (Constant)
Data Set	4	5	A5	Data set code number. First digit is last digit of sample year, i.e., 19th sample of 1976 is 60019.
Sample Date	9	6	3I2	Month, day, year of sample
Site	15	10	A6, A4	Collection Site (GCFC notation)
Source	25	12	2A6	Name of agency or person from whom sample was obtained
Description	37	43	7A6, A1	Sample description
Data Source Code	1	2	I2	"62" (Constant)
Card Type	3	1	I1	"2" (Constant)
Data Set	4	5	A5	Data set code number. (Must agree with card 1)
Analysis Date	9	6	3I2	Month, day, year of analysis
Analyst	15	12	2A6	Name of Analyst
Examination Type	27	2	A2	GC = sample examined by gas chromatography MS = sample examined by mass spectrometry
Amount Analyzed	29	8	F8.4	Amount of sample analyzed in grams
Comments	37	43	7A6, A1	Comments on Analysis
Data Source Code	1	2	I2	"62" (Constant)
Card Type	3	1	I1	"3" (Constant)

HYDROCARBONS

Field Name	Position	Length	Format	Use and Meaning
Data Set	4	5	A5	Data set code number. (Must agree with card 1 and card 2)
Compound	9	40	6A6, A4	Compound name or abbreviation (i.e., NC20 = n-eicosane, the n-alkane with 20 carbon atoms per molecule)
Concentration	49	6	A6.0	Compound concentration (number or the word TRACE. The decimal, if any, should be included in number).
Unit	55	1	A1	C = percent M = parts per million B = parts per billion T = parts per trillion
Comment	56	24	4A6	Comments on individual compounds

HYDROCARBONS

SOURCE	CODE	CARD TYPE	DATA SET	SAMPLE DATE MO	SAMPLE DATE DAY	SAMPLE DATE YR	SITE	SOURCE	COMMENTS
1	2	3	4 5 6 7 8	9 10	11 12	13 14	15 16 17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32 33 34 35 36	37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
6	2	1							

SOURCE	CODE	CARD TYPE	DATA SET	ANALYSIS DATE MO	ANALYSIS DATE DAY	ANALYSIS DATE YR	ANALYST	EXAMINATION TYPE	AMOUNT ANALYZED (GRAMS)	COMMENTS
1	2	3	4 5 6 7 8	9 10	11 12	13 14	15 16 17 18 19 20 21 22 23 24 25 26	27 28	29 30 31 32 33 34 35 36	37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

SOURCE	CODE	CARD TYPE	DATA SET	COMPOUND	CONCENTRATION	UNIT	COMMENTS
1	2	3	4 5 6 7 8	9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	49 50 51 52 53 54	55	56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

Field Name	Position	Length	Format	Use and Meaning
File Type	1	3	I3	"001" (constant)
Record Type	4	1	I1	"1" (constant)
Station	5	5	A5	Station Number
Date	10	6	3I2	Month, day, and year of sample
Time	16	4	I4	Time of sample (24 Hour Clock))
Latitude	20	6	3I2	Degrees, minutes, seconds
Lathem	26	1	A1	Hemisphere "N" or "S"
Longitude	27	7	I3, 2I2	Degrees, minutes, seconds
Lonhem	34	1	A1	Hemisphere "E" or "W"
Navigation	35	2	I2	(see attached codes)
Sample Depth	37	6	F6.1	Sample depth to tenths of a meter
Bottom Depth	43	6	F6.1	Water depth to tenths of a meter
Secchi	49	5	F5.1	Secchi Disk Depth; to tenths of a meter
Barometric Pressure	54	5	F5.2	Barometric pressure to hundreth of a millibar
Dry Bulb	59	4	F4.1	Air temperature to tenths of degrees celsius
Wet Bulb	63	4	F4.1	Air temperature to tenths of degrees celsius
Water Temperature	67	4	F4.1	Water temperature to tenths of degrees celsius
File Type	1	3	I3	"001" (constant)
Record Type	4	1	I1	"2" (constant)
Station	5	5	A5	Station Number
Date	10	6	3I2	Month, day, and year of sample
Time	16	4	I4	Time of sample (24 Hour Clock)
Sequence	20	2	I2	Sequence Number of type 2 cards for this station
Species	22	24	4A6	Species name or code for sediment (S) or code for water (W)

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

Field Name	Position	Length	Format	Use and Meaning
Sex	46	1	A1	M = Male F = Female blank = both sexes used, unknown or not applicable
Count	47	3	I3	Number of animals in sample
Material Analyzed	50	2	I2	(See attached code)
Length	52	5	I5	Average length of specimens to whole millimeters
Weight	57	6	I6	Average weight of specimens to whole grains
Sample State	63	2	I2	(See attached codes)
Percent Dry	65	4	F4.2	Dry weight percent of wet weight to hundreths. Initial determination
Drying Temperature	69	4	F4.2	Initial determination; °C to nearest degree
Percent Dry	73	4	I4	Dry weight percent of wet weight to hundredths. Determination at analysis
Drying Temperature	77	4	I4	At analysis, °C to nearest degree
File Type	1	3	I3	"001" (constant)
Record Type	4	1	I1	"3" (constant)
Station	5	5	A5	Station Number
Date	10	6	3I2	Month, day and year of sample
Time	16	4	I4	Time of sample (24 Hour Clock)
Sequence	20	2	I2	Sequence Number of type 3 cards for this station
Species	22	24	4A6	Species name or code for sediment (S) or code for water (W)
Element Analyzed	46	2	A2	Standard element abbreviation
Method of Analysis	48	3	A3	(See attached code)
Date of Analysis	54	6	3I2	Month, day, year of analysis

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

Field Name	Position	Length	Format	Use and Meaning
Concentration				
Replicate 1	57	6	2I3	Expressed in parts per million (ppm) in scientific notation to three significant digits, i. e., 1.11 ppm = 111 + 00 0.111 ppm = 111 - 01 11.1 ppm = 111 + 01
Replicate 2	63	6	2I3	
Replicate 3	69	6	2I3	
Replicate 4	75	6	2I3	

SPECIAL CODES
TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER FILE (type "100")

NAVIGATION CODE

01 = Loran (mixed or unspecified)
02 = Radar and/or fixes
03 = Raydist without complications
04 - Raydist with errors, drifting, etc.
05 = Satellite
06 = Omega
07 = Loran A only
08 - Loran B only
09 = Loran C only

MATERIAL ANALYZED CODE

01 = Muscle
02 = Liver
03 = Digestive gland
04 = Conad
05 = Gills
06 = Kidney
07 = Spleen
08 = Heart
09 = Brain
10 = Blood
11 = Stomach contents
12 - Tom 1 1/2" of sediment core
13 = Middle 1 1/2" of sediment core
14 = Remainder of sediment core
15 = Whole organism
16 = Water
17 = Particulate matter

SAMPLE STATE CODE

01 = Fresh frozen
02 = Freeze dried
03 = Oven dried at 105-115°C
04 = Formaldehyde preserved
05 = Oven dried at 60°C
06 = Fresh, preserved at 33-40°F
07 = Raw
08 = Cooked
09 = Canned

SPECIAL CODES

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER FILE (type "100")

METHOD OF ANALYSIS

W = Data expressed on wet weight basis
D = Data expressed on dry weight basis

followed by:

01 = Milford dry ashing method
02 = Repetitive wet ash method using 30 ml. HNO_3
03 = Mercury analysis - flameless AA
04 = Standard sediment method - 50% HNO_3 extraction
05 = Kosiesza - Anal. Services, Inc., arsenic method
06 = Kosiesza - Anal. Services, Inc., Cd, Cr, Pb method
07 = Nondestructive neutron activation
08 = Milford arsenic method
09 = Mercury in sediment, EPA aqua regia method
10 = Wet ash, concentrated HNO_3 method from "Marine Pollution Monitoring: Strategies for a National Policy." Edited by Dr. Edward Goldberg, Scripps Institution of Oceanography

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

FILE TYPE	RECORD TYPE	STATION NUMBER	DATE			SAMPLE TIME (24 HOUR CLOCK)	LATITUDE				LONGITUDE				NAVIGATION CODE	SAMPLE DEPTH (M)	BOTTOM DEPTH (M)	SECCHI (M)	BAROMETRIC PRESSURE (MB)	DRY BULB (°C)	WET BULB (°C)	WATER TEMPERATURE (°C)	
			MO	DAY	YR		DEG	MIN	SEC	N OR S	DEG	MIN	SEC	E OR W									
1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23	24 25	26	27 28 29	30 31	32 33	34	35 36	37 38 39 40 41 42	43 44 45 46 47 48	49 50 51 52 53	54 55 56 57 58	59 60 61 62	63 64 65 66	67 68 69 70	71 72 73 74 75 76 77 78 79 80
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TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

FILE TYPE	RECORD TYPE	STATION NUMBER	DATE			SAMPLE TIME (24 HOUR CLOCK)	SEQUENCE NUMBER	SPECIES	SEX	MATERIAL ANALYZED	COUNT	LENGTH (MM)	WEIGHT (GR)	SAMPLE STATE	PERCENT DRY	DRYING TEMP (°C)	PERCENT DRY	DRYING TEMP (°C)
			MO	DAY	YR													
1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22–45	46	47 48	49 50 51	52 53 54 55 56	57 58 59 60 61 62	63 64	65 66 67 68	69 70 71 72	73 74 75 76	77 78 79 80
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TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

FILE TYPE	RECORD TYPE	STATION NUMBER	DATE			SAMPLE TIME (24 HOUR CLOCK)	SEQUENCE NUMBER	SPECIES	ELEMENT ANALYZED	METHOD OF ANALYSIS	DATE OF ANALYSIS			CONCENTRATION			
			MO	DAY	YR						MO	DAY	YR	REPLICATE 1	REPLICATE 2	REPLICATE 3	REPLICATE 4
1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44	45 46	47 48 49 50	51 52	53 54	55 56	57 58 59 60 61 62	63 64 65 66 67 68	69 70 71 72 73 74	75 76 77 78 79 80
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TOTAL ORGANICS

Field Name	Position	Length	Format	Use and Meaning
Record Type	1	2	I2	"51" (constant
Date	3	6	3I2	Month, day and year of sample
Station	9	5	A5	Station Number
Sample Number	14	5	A5	Sample Number
Total Organic Carbon	19	4	F4.1	Total Organic Carbon to hundredths of a percent
Stable Carbon Isotope Ratio	23	5	F5.1	Ratio of stable carbon Isotope (del-C-13) to tenths Col 27 = sign (±)
Unstable Carbon Isotope Ratio	28	5	F5.1	Ratio of Unstable Carbon Isotope (del-C14) to tenths Col 22 = sign (±)
Radiocarbon Age	33	8	2I4	Radiocarbon Age in years to hundreds of years Col 14 = sign (±) i.e., 1500 ± 200
Depth	41	6	F6.1	Sample Depths in cm to tenths
Remarks	47	34	5A6, A4	Remarks

TOTAL ORGANICS

RECORD TYPE	DATE			STATION	SAMPLE NUMBER	TOTAL ORGANIC CARBON (%)	STABLE CARBON ISOTOPE RATIO Tdel C 13	UNSTABLE CARBON ISOTOPE RATIO Tdel C 14	RADIOCARBON AGE	DEPTH (CM)	REMARKS
	MO	DAY	YR								
1 2	3 4	5 6	7 8	9 10 11 12 13	14 15 16 17 18	19 20 21 22	23 24 25 26 27	28 29 30 31 32	33 34 35 36 37 38 39 40	41 42 43 44 45	46 … 80
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APPENDIX 2

DATA LOG AND CONTROL FORMS

DATA LOG AND CONTROL FORM

Task 2.3.4

Title EPA-FAUNA SURVEY

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
5/13/76	1/17/77	1/25/77	2/4/77				
5/14/76	1/17/77	1/25/77	2/4/77				
5/15/76	1/17/77	1/25/77	2/4/77				
5/16/76	1/17/77	1/25/77	2/4/77				
8/9/76	1/17/77	1/25/77	2/4/77				
8/10/76	1/17/77	1/25/77	2/4/77				
8/11/76	1/17/77	1/25/77	2/4/77				
8/12/76	1/17/77	1/25/77	2/4/77				
11/15/76	1/17/77	1/25/77	2/4/77				
11/17/76	1/17/77	1/25/77	2/4/77				
11/18/76	1/17/77	1/25/77	2/4/77				
11/19/76	1/17/77	1/25/77	2/4/77				
2/15/77	3/17/77	3/25/77	3/27/77				
2/16/77	3/17/77	3/25/77	3/27/77				

DATA LOG AND CONTROL FORM

Task 2.3.5

Title DIMERSAL FISH

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
6/9/76	4/25/77	5/3/77					
6/11/76	4/25/77	5/3/77					
8/2/76	4/25/77	5/3/77					
8/4/76	4/25/77	5/3/77					
8/5/76	4/25/77	5/3/77					
8/6/76	4/25/77	5/3/77					
8/31/76	4/25/77	5/3/77					
9/12/76	4/25/77	5/3/77					
9/23/76	4/25/77	5/3/77					
9/24/76	4/25/77	5/3/77					
11/1/76	4/25/77	5/3/77					
11/6/76	4/25/77	5/3/77					
11/23/76	4/25/77	5/3/77					
12/3/76	4/25/77	5/3/77					
12/16/76	4/25/77	5/3/77					
12/17/76	4/25/77	5/3/77					
1/21/77	4/25/77	5/3/77					

DATA LOG AND CONTROL FORM

Task 2.3.5

Title DIMERSAL FISH

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
2/13/77	4/25/77	5/3/77	5/8/77				
3/7/77	4/25/77	5/3/77	5/8/77				

DATA LOG AND CONTROL FORM

Task 2.3.6

Title ICHTHYOPLANKTON

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
5/24/76	4/22/77	4/28/77	5/5/77	5/24/77			
5/25/76	4/22/77	4/28/77	5/5/77	5/24/77			
8/16/76	4/22/77	4/28/77	5/5/77	5/24/77			
8/17/76	4/22/77	4/28/77	5/5/77	5/24/77			
12/3/76	4/22/77	4/28/77	5/5/77	5/24/77			
12/4/76	4/22/77	4/28/77	5/5/77	5/24/77			
2/19/77	4/22/77	4/28/77	5/5/77	5/24/77			

DATA LOG AND CONTROL FORM

Task 2.3.8

Title PLATFORM STUDIES - BIRD SAMPLES

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
5/15/76	12/9/76	2/14/77	2/21/77	5/23/77			
5/16/76	12/9/76	2/14/77	2/21/77	5/23/77			
5/22/76	12/9/76	2/14/77	2/21/77	5/23/77			
5/22/76	12/9/76	2/14/77	2/21/77	5/23/77			
7/10/76	12/9/76	2/14/77	2/21/77	5/23/77			
7/11/76	12/9/76	2/14/77	2/21/77	5/23/77			
7/22/76	12/9/76	2/14/77	2/21/77	5/23/77			
7/24/76	12/9/76	2/14/77	2/21/77	5/23/77			
7/25/76	12/9/76	2/14/77	2/21/77	5/23/77			
7/29/76	12/9/76	2/14/77	2/21/77	5/23/77			
9/4/76	12/9/76	2/14/77	2/21/77	5/23/77			
9/5/76	12/9/76	2/14/77	2/21/77	5/23/77			
9/8/76	12/9/76	2/14/77	2/21/77	5/23/77			
9/11/76	12/9/76	2/14/77	2/21/77	5/23/77			
9/12/76	12/9/76	2/14/77	2/21/77	5/23/77			
9/17/76	12/9/76	2/14/77	2/21/77	5/23/77			
12/16/76	12/9/76	2/14/77	2/21/77	5/23/77			

DATA LOG AND CONTROL FORM

Task 2.3.8

Title PLATFORM STUDIES - BIRD SAMPLES

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
12/18/76	2/7/77	2/14/77	2/21/77	5/23/77			
12/19/76	2/7/77	2/14/77	2/21/77	5/23/77			
1/8/77	2/7/77	2/14/77	2/21/77	5/23/77			
1/9/77	2/7/77	2/14/77	2/21/77	5/23/77			

DATA LOG AND CONTROL FORM

Task 2.3.8

Title PLATFORM STUDIES - SESSILE FAUNA QUADRAT

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
9/13/76	3/7/77	3/24/77	5/3/77				
10/1/76	3/7/77	3/24/77	5/3/77				
10/2/76	3/7/77	3/24/77	5/3/77				
11/1/76	3/7/77	3/24/77	5/3/77				
1/22/77	4/5/77	4/20/77	5/3/77				
1/21/77	4/5/77	4/20/77	5/3/77				
12/29/76	4/5/77	4/20/77	5/3/77				

DATA LOG AND CONTROL FORM

Task 2.3.8

Title PLATFORM STUDIES - FISH DETERMINATION

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
10/1/76	4/27/77	5/1/77	5/5/77				
11/1/76	4/27/77	5/1/77	5/5/77				
3/8/77	4/27/77	5/1/77	5/5/77				

DATA LOG AND CONTROL FORM

Task 2.3.8

Title PLATFORM STUDIES - PLANKTON SAMPLES

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
5/24/76	8/2/76	10/14/76	12/3/76				
8/10/76	4/22/77	5/1/77	5/5/77				
10/1/76	4/22/77	5/1/77	5/5/77				
10/2/76	4/22/77	5/1/77	5/5/77				
11/2/76	4/22/77	5/1/77	5/5/77				
12/9/76	4/22/77	5/1/77	5/5/77				

DATA LOG AND CONTROL FORM

Task 2.3.9

Title HYDROGRAPHY - DRIFT BOTTLE RELEASE/RECOVERY

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
5/24/76	11/30/76	12/9/76	2/21/77				
6/11/76	11/30/76	12/9/76	2/21/77				
7/1/76	11/30/76	12/9/76	2/21/77				
7/7/76	11/30/76	12/9/76	2/21/77				
7/13/76	11/30/76	12/9/76	2/21/77				
7/20/76	11/30/76	12/9/76	2/21/77				
7/27/76	11/30/76	12/9/76	2/21/77				
5/25-29/76	1/3/77	1/14/77	2/21/77				
7/2/76	1/3/77	1/14/77	2/21/77				
7/28/76	1/3/77	1/14/77	2/21/77				
8/10/76	1/3/77	1/14/77	2/21/77				
8/11/76	1/3/77	1/14/77	2/21/77				
8/12/76	1/3/77	1/14/77	2/21/77				
8/16-21/76	1/3/77	1/14/77	2/21/77				
8/31/76	1/3/77	1/14/77	2/21/77				
9/23/76	1/5/77	1/14/77	2/21/77				
10/18/76	1/5/77	1/14/77	2/21/77				

DATA LOG AND CONTROL FORM

Task 2.3.9

Title HYDROGRAPHY - DRIFT BOTTLE RELEASE/RECOVERY

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
11/11/76	1/5/77	1/14/77	2/21/77				
11/30/76	1/5/77	1/14/77	2/21/77				
12/1-4/76	1/5/77	1/14/77	2/21/77				
1/17/77	2/3/77	2/10/77	3/5/77				
1/18/77	2/3/77	2/10/77	3/5/77				
2/18-26/77	3/17/77	3/25/77	4/21/77				

DATA LOG AND CONTROL FORM

Task 2.3.9

Title HYDROGRAPHY - OCEANOGRAPHIC DATA

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
5/24-30/76	2/3/77	2/10/77	2/27/77	5/19/77			
7/7/76	2/3/77	2/10/77	2/27/77	5/19/77			
8/11-12/76	2/3/77	2/10/77	2/27/77	5/19/77			
8/16-21/76	2/3/77	2/10/77	2/27/77	5/19/77			
9/23-24/76	2/3/77	2/10/77	2/27/77	5/19/77			
10/18/76	2/3/77	2/10/77	2/27/77	5/19/77			
11/11/76	2/3/77	2/10/77	2/27/77	5/19/77			
12/1-4/76	2/3/77	2/10/77	2/27/77	5/19/77			
1/17-18/77	2/3/77	2/10/77	2/27/77	5/19/77			
2/18-3/3/77	3/21/77	3/28/77	4/3/77	5/19/77			

DATA LOG AND CONTROL FORM

Task 2.4.1

Title HYDROCARBONS

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
4/1/76	9/29/76	11/17/76					

DATA LOG AND CONTROL FORM

Task 2.4.3

Title TOTAL ORGANICS

MISSION DATE	DATE REC.	DATA KEY PUNCHED	DATA CONVERSION	DATA ENTERED INTO DATA BASE	DATA TO EDS	DATA REQUESTED	
						REQUESTED	SENT
6/18/76	5/3/77	5/8/77	5/11/77				
9/8/76	5/3/77	5/8/77	5/11/77				
9/9/76	5/3/77	5/8/77	5/11/77				
9/10/76	5/3/77	5/8/77	5/11/77				
11/2/76	5/3/77	5/8/77	5/11/77				
11/3/76	5/3/77	5/8/77	5/11/77				

SEDIMENTOLOGY, GEOCHEMISTRY AND TRACE METAL ANALYSIS

Principal Investigators

John B. Anderson

R. R. Schwarzer

Associate Investigator

H. C. Clark

EXECUTIVE SUMMARY

Marine geologic investigation of the Buccaneer Oil/Gas Field began on May 4, 1976 with the first cruise on board the R.V. GUS III. Since that time a thorough geophysical sedimentologic and geochemical study has been completed.

High resolution seismic profiling was conducted along ¼-mile spaced tracks. Two prominent reflectors were detected and mapped. These data indicate that the area does contain faults and that these features play a critical role in influencing surface sediment patterns. A magnetic survey was also conducted along these same tracks using a Geometrics 806 proton magnetometer. Results from this study led to the construction of a revised pipeline location map which shows pipeline displacement ranges from a few tens of meters to more than 100 meters. Our sidescan sonar survey showed no significant large-scale sedimentary structures and/or scour zones within the field or control areas.

Sediment samples were analyzed for size distribution, clay mineralogy and heavy mineralogy. Sediments within the study area display highly variable textural properties which, no doubt, reflect scour and redeposition by bottom currents and reworking of ancient sediments. A distinct bottom suspended sediment layer exists within the area during summer months. Although the exact source of this material was not determined, it may serve as a source and/or sink for chemical contaminants. Additional study of this suspended sediment layer is recommended.

Trace metal concentrations for bottom sediment samples do show enriched concentrations of Pb, Zn, and Sr near both platforms A and B and near one of the satellite platforms. Analyses of organisms, including fish, shrimp, squid, plankton and barnacles, were also conducted. For the most part, trace metal concentrations are at normal levels with the exception of high Cd (up to 25 PPM) and Sr (up to 100 PPM) levels in several barnacle specimens. The source of these contaminants is, as of yet, unknown.

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INTRODUCTION

Marine geologic investigation of The Buccaneer Oil Field began on May 4 with the first cruise on board the R.V. Gus III. Since then numerous expeditions to the field area have been completed.

Perhaps the most striking aspect of this project has been the discovery that the study area, though small in size, comprises a complex geologic setting in which several distinct sedimentary facies exist. This complexity is, in part, due to the fact that ancient deposits are exposed in parts of the area and along with modern sediments, are being acted upon by both wave and bottom current action. These processes, in turn, influence geochemical processes and must be well understood before interpretation as to the effects of offshore drilling upon this environment can be made. This system can best be understood through careful modeling of the interrelationships between physical, chemical and geological processes.

METHODS

Sediment Analysis

Sediment cores were obtained using a large (6 inch barrel diameter) coring device. Where the use of a heavy coring device was not feasible, as in coarse bottom sediments; or dangerous, as near submerged pipelines, a small snub nose (6 inch long barrel) core and/or ponar grab were used. Sediment samples were described on board the vessel, capped or placed in plastic bags and refrigerated. The format for sediment analysis used in this study is illustrated in figure 1.

Sediment cores were x-radiographed prior to extrusion. Once removed from their liners cores were sampled with a teflon spatula for geochemical analysis. The remaining surface sample was dried and weighed. Weighed samples were then dispersed overnight in Calgon solution and wet-sieved through a 63μ screen. The greater then 63μ subsample was then dried, weighed and sieved at 1/4Ø intervals. The biogenic and non-biogenic composition of each >63μ subsample is then determined microscopically.

Heavy mineral separation of the 63-250μ fraction was conducted using Bromoform (s.g. 2.89 at 20°C) and partial freezing using liquid nitrogen. Light and heavy fractions and the important mineral species were determined using standard petrographic techniques.

Clay mineral analyses (as % Illite, % Kaolinite, and % Expandable Clays) were conducted in the following manner:

A. Sample Preparation

Samples were dispersed overnight in Calgon solution and wet-sieved through a 63 screen. The <63 size fraction is shaken to suspend all material and allowed to settle for 4 hours. An aliquot of 20 ml of water plus sample is drawn from the top 5 cm so as to sample the less than 0.004 mm fraction. The clay plus water slurry was poured onto a glass plate and allowed to dry in a closed environment.

B. X-ray Analysis

Three x-ray powder diffraction scans were made for each sample. A Natural scan allowed identification of all major components (clay andnon clay minerals) and an estimation of the expandable clay mineral (001) sharpness. All samples were placed in ethylene glycol vapor at approximately 75°C for 2 hours. The Glycolated scan enabled recognition of the expandable clay mineral component. All samples were heated at 300°C for 24 hours. The Heated scan allowed determination of the amount of 10Å material (illite plus collapsed expandables). Quantification procedures are described in Taber (1971).

The x-ray diffraction patterns were run and interpreted by Dr. John Butler, University of Houston.

Chemical Analysis

One gram samples were treated with 0.5 ml Sodium Hypochlorite and 2.5 ml of 50% reagent strength nitric acid. Samples were heated until reaction is completed and centrifuged to remove insoluble residues. The solution was then diluted to a 50 ml volume with distilled water to yield a 2% concentration.

Biological samples (approximately one gram) were dried, weighed, ground and homogenized and placed in a refluxing system with 10 ml of 3:1 HNO_3:$HClO_4$. Refluxing was allowed to continue until $HClO_4$ fumes were evolved and the sample was evaporated to near dryness. Insoluble residues were then removed by centrifuging and the sample diluted with distilled water.

Samples were analyzed using a Perkin Elmer Model 360 Atomic Absorption-Emission Spectrophotometer. A nitrous oxide flame was used in making Ba analyses.

Suspended Sediment Investigation

Turbidity - Temperature profiles were obtained using a Hydroproducts Model 410-BR Transmissiometer and Industrial Instruments Model RS5-2 salinometer-temperature probe. Water samples were obtained using a submersible pump and stored in 5 gallon plastic water containers. Samples were filtered using .45$_\mu$ Gelman Metricel filters which were preweighed. Filters were then washed with distilled water to remove salts, dried and weighed. Filters were cut into small strips and treated with 5 ml NaOCl (Sodium hypochlorite). Next 10 ml of 50% reagent strength Nitric Acid was added and heated for approximately 5 minutes. The solution was centrifuged and brought to 25 ml with distilled water. Analyses were conducted by AA methods described under the section on Chemical Analysis. A blank filter was also analyzed for trace metal concentration.

Seismic Measurements

The seismic investigation of the Buccaneer Oil Field required instrumentation capable of delineating the basic geological framework of the near surface structure in the field area. To accomplish this, we chose a high resolution, shallow penetration, Acoustipulse (Bolt, Bernek, Newman) continuous profiling system. This system uses the "boomer" principle transducer which involves a plate which is repelled when an electric pulse is discharged through a coil adjacent to it. For the Buccaneer survey, three transducers, using 500 joules each, were mounted on a catamaran towed about 25 meters behind the ship and at a depth of approximately a meter below the sea surface. It may be noted here that a major source of diminished record quality is from a wave height of greater than about 1 meter. Under these conditions the catamaran would be lifted out of the water and air cavitation beneath the transducer plates would destroy the output pulse. This is noted on the particular records. No problems are encountered with the receiving hydrophone, towed approximately parallel with the transducers, or the 19" dry paper recorder (EPC4100). The incoming signal was filtered for the band 400 to 4,000 kz. The BBN Acoustipulse system was mobilized on board the Gus III beginning April 23 utilizing Rice University, NOAA and BBN personnel. After several delays due to weather, the cruise left Galveston on May 2nd. All instruments responded positively to tests and the survey was completed on May 4th with only minor instrument failure. The BBN measurements were supervised by Herman Sieck and the installation and operation of the instruments was carried out by John Doherty.

The cruise track is shown in the accompanying figure 2. Line location was controlled by Lorac and lines were spaced at 1/4 mile intervals. We were particularly concerned with adequate coverage in the area of the platforms, as well as possible sediment source areas.

Magnetic Survey

The magnetic profiling of the Buccaneer Oil Field required an instrument capable of detecting pipelines of varying diameters buried at shallow depths. A Geometrics 806 proton magnetometer was utilized for this purpose. It has a sensitivity of 1 gamma and a noise level of 1 to 3 gammas, depending on the sea state. The proton magnetometer has the advantage of being independent of system orientation and measures the total geomagnetic field. The towed fish was deployed about 30 meters behind the ship. The magnetic survey was performed synchronously with the seismic survey. Thus, the magnetic and seismic profile lines are the same. In addition, several profiles were made near platforms. The calculations for the magnetic interpretation were done by Ms. C. K. Watson.

Sidescan Sonar

The objective of the sidescan sonar survey was to determine whether or not seafloor surface disturbances exist which may influence sediment distribution. We chose an EG&G sidescan sonar system which uses a high frequency transducer with a narrow horizontal and wide vertical beam. The receiver uses an internal time varying gain and filter and records on wet paper. The survey was controlled by ships navigation and the track lines are described in fig. 3.

The survey was performed aboard the Gus III on November 21, 1976. H. C. Clark was the system operator and John Anderson, Rudy Schwarzer, and Rich Wheeler participated with the operator in the interpretation. The scan was operated on the 50 or 150 meter scale. Ship speed was between 2 and 4 knots depending on the tow depth desired.

Application of Multivariate Statistical Techniques

Multivariate statistical techniques were used to investigate the following:

1) redundancy in the variables analyzed.
2) an objective surface sediment facies map based on sedimentary size parameters.
3) the existence of a hierarchical classification of the sedimentary size parameters.
4) the existence of geochemical coherence patterns within the analyzed trace elements.
5) the relationships between trace element concentrations and sedimentary parameters.

The results of items 1, 2 and 3 above are reported later in the section on results. Items 4 and 5 will be investigated in the near future and reported at a later date.

Several classes of techniques are available to carry out a multivariate analysis on a given body of information. Eigenvalue techniques, such as factor and principal component analysis, have found much use in the behavorial sciences (Harmon, 1967) and are generally thought to be quite powerful. However, these techniques require a number of restrictive assumptions regarding properties of the original data before meaningful results may be obtained. These restrictions involve assumptions of normality, and various aspects of communality on the main diagonal of the correlation matrix (Cattell, 1965 a,b). It is felt that data gathered in this study will not meet the rather restrictive standards required for meaningful application of any of the available eigenvalue techniques, therefore, less restrictive, multivariate analytical techniques must be sought.

The similarity matrix techniques, cluster analysis and ordination, require none of the restrictive assumptions concerning communality or distribution necessary for the eigenvalue techniques and are, therefore, ideally suited to the needs of data gathered here. Data from other areas of scientific endeavor displaying similar properties to data from this investigation have been successfully interpreted using cluster analysis and ordination. For example, see Schwarzer (1973), Gevirtz et al. (1971), Gevirtz and Schwarzer (1976) for geological applications and Orloci (1969) and Cole (1969) for ecological applications. Data in the above studies are similar to some of the data obtained in this study in that the distribution underlying them is unknown; therefore, the rather restrictive assumption of normality cannot generally be made, rendering the use of eigenvalue techniques unreliable.

The techniques used in this study search for, and display, similarities and differences between samples as shown in a similarity matrix consisting of an array of similarity coefficients derived from an array of samples in which several attributes have been measured in each. The relationships existing between samples (Q mode) or attributes (R-mode) may be expressed in either of two forms: 1) as a hierarchical classification of samples or attributes (cluster analysis); or 2) as a continuum based on relationships between samples or attributes and samples selected as endpoints (ordination).

Similarity matrix techniques do not have available any good test of significance. What is normally done is that if scientifically sound results are obtained, they are accepted, while if the results are not sound, the parameters are altered and the analysis is repeated. Because of these difficulties, cluster analysis and ordination are not used as an end in themselves, but as a means for generating ideas that can be tested independently by using data not included in the analysis. Used in this way, these techniques have proved to be very successful.

RESULTS AND INTERPRETATION

Sedimentology

Sediment samples were obtained from 93 stations within the area (Figs. 4 and 5) itself and at 14 stations outside the area. X-radiographs of sediment cores reveal very little in the way of sedimentary structures. A few cores do contain faint laminations, but most are extremely bioturbated. Homogenization of surface sediments by organisms is a critical process in that it results in dispersion of chemical contaminants throughout the upper few centimeters of bottom sediment. In addition, persistent agitation by benthic organisms, no doubt, results in loss of fine sediments by continuously re-exposing this material. The extent to which this process may influence geochemical trends is discussed in the geochemistry section of this report.

The character of sediments found within the study area is, rather surprisingly, quite variable (Table 1). Figure 6 shows the sand/silt/clay concentrations for samples taken from in and around the study area. Most samples consist of greater than 50% sand and reflect high energy bottom conditions within the study area. Using Shepard's (1954) classification (Fig. 6) four distinct sediment facies are recognized within the study area. These consist of sand, clayey sand, silty sand and sand-silt-clay. Samples taken in the northeastern portion of the area consist of gravel size shell debris and comprise a fifth facies (Fig. 7).

Although the origin of various sediment types within the study area is yet uncertain, some observations can be made. Shell gravels probably represent ancient deposits re-exposed by bottom currents and perhaps structural uplift. Seismic records for this area do show structural offset along a northeast-southwest trending fault which extends from the approximate area of platform A through the northeastern edge of the area. This area is only slightly elevated with respect to the adjacent seafloor.

Shell gravels are bound on the southeast by a narrow northeast-southwest trending near surface exposure of clay. This clay may also represent ancient sediments, perhaps the Pleistocene Beaumont Formation, as suggested by Scrudato (1976) in the pilot report for this project.

The occurrence of these ancient deposits within the northeastern portion of the area indicates very slow sedimentation, and perhaps erosion of sediments in this area today. That bottom currents do, in fact, sweep the bottom is further suggested by a map of sand/mud ratios for samples taken in the area (Fig. 8). Transportation of fine sediments from northeast to southwest is suggested; the source of this fine material being the exposed Beaumont surface which is shaded in this figure. Mid-depth current measurements obtained by NOAA personnel (John Martin, oral presentation at October meeting of Principal Investigators in Galveston) are up to 25 cm/sec. Currents of this magnitude are sufficiently competent to erode and transport sediments of up to .4 mm diameter, as determined from Heezen and Hollister's (1964) curves.

The implications of these data are important to the Buccaneer study as a whole. Trace metals introduced into the system will most likely be bound either by clay minerals or by organic substances. Bottom currents capable of winnowing and redistributing clays and organic debris will, therefore, exert considerable influence on the distribution of chemical contaminants as well. Further discussion of these influences are deferred to the section on geochemistry in this report.

The poorly sorted sand-silt-clay facies which occur in the eastern-most corner of the area probably results from an admixing of exposed Beaumont Clay with modern sandy sediments. The silty sand and sand facies are gradational with one another, and cover the bottom over most of the area. Three samples taken in the southwestern corner of control area Y consist of clayey sand and may reflect near surface exposure of Beaumont Clay in this area. Additional long cores from this area will hopefully help in the interpretation of these deposits.

Sediment samples taken within 375 feet of platforms A and B are, for the most part, sandier than sediments on the surrounding seafloor and show considerable variation in sand/mud ratios (Fig. 9). This reflects bottom scouring, probably by eddies which result from currents flowing past the legs of these structures. Again, sedimentary data add valuable insight into seafloor processes of the study area and stand as a strong warning against oversimplification of geochemical interpretation. If scouring is indeed common around structures, then it is very likely that contaminants will be swept from these areas. Certainly variations in concentrations of contaminants near structures should be viewed in light of possible scouring effects. The possibility of such influences is deferred to the section on geochemistry in this report.

Where bottom currents are suspected of influencing sedimentation, sedimentary structures may reflect the extent of this influence. As previously mentioned, X-radiographs show little evidence of sedimentary structures due to extreme bioturbation. As part of the sedimentologic investigation, side-scan sonar was used to look for larger bottom features and for evidence of major scouring near platforms. Profiles were taken around platforms A and B to look for scouring and along two transects within the northeastern part of the area where strong bottom current action is suspected (Fig. 3). No observable evidence of scouring was obtained near the structures (Fig. 10). Also, large bottom features were not detected on those transects taken. The absence of scour zones and bottom structures does not, however, negate the sedimentologic evidence for current activity.

Mineralogy - Heavy Minerals

Samples taken from the study area generally contain less than 0.50 percent by volume heavy minerals. Hornblende is the most commonly occurring mineral, averaging 50% of the heavy mineral assemblage in those samples counted. Other commonly occurring heavy minerals include epidote and pyroxenes (averaging 15% each). Results from heavy mineral analyses for this study are consistent with results of Van Andel and Poole (1960) for this area of the Gulf of Mexico and fall within the zone of mixing between their Western Gulf province and Mississippi province. The former mineralogic province is believed derived from the Colorado River as well as from the Mississippi and Rio Grande Rivers and the Mississippi province from glacial deposits (Van Andel and Poole, 1960). See Table 1 for the weight percent of heavy minerals in those samples analyzed.

Mineralogy - Clay Minerals

The clay and nonclay mineralogy of the study area is quite similar in all samples (Table 2) and quite similar to clay suites from the Texas Gulf Coast (John Butler, personal communication, 1977). The only significant difference between samples from the study area seems to be the sharpness of the (001) reflection of the expandable clays as indicated by S, S^-, or B in Table 2 and shown in Figure 11. The variation in sharpness is probably the result of variation in "crystallinity" of the expandable phases. A possible explanation for this is the presence of drilling muds in the study area. The bentonite clays used in most drilling muds contain well crystallized montmorillonite (an expandable clay). Since all but one of the samples showing a peak sharpness of S or S^- (see Table 2 and Figures 12 and 13) were collected within 375' of drilling structures this appears to be a reasonable explanation. However, there is one field sample (#76) from the SW edge of the study area that also showed a sharp (001) expandable clay reflection (see Figure 12).

Geochemistry

Sediment samples acquired for this study were analyzed for Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sr, and Zn. For the most part, the concentrations of individual metals vary only slightly within the field area (Table 3) except near platforms A and B and the well jacket (Table 4).

Table 5 compares the trace metal concentrations of sediment samples from the Buccaneer Field Study with similar data from BLM's South Texas Outer Continental Shelf Study. The Buccaneer data is further subdivided into field stations (figure 4) versus stations collected within 375' of structures (figure 5). Note that for most elements the BLM and Buccaneer field station data are quite similar.

As can be seen from the table, there appears to be enrichment of Ba, Pb, Zn, and Sr near the structures as compared to field stations. For example, Pb concentrations for samples taken from throughout the study area average 13.2 PPM and range from 8.3 PPM to 53.8 PPM (Fig. 14). These subtle variations are hardly indicative of major contamination. However, Pb concentrations of samples taken within 375 feet of structures are commonly much higher, up to 97 PPM, and generally decrease away from these structures (Fig. 15). In a similar manner, Zn, whose average concentration in sediment samples throughout the area is 39.9 PPM (Fig. 16), is enriched in those sediment samples taken within 375 feet of structures (53.0 PPM average; see figure 17). The Ba concentrations are significantly lower for samples from field stations (Ave. 144 PPM, Figure 18). Sr appears to be concentrated near the drilling platforms as well as near the well jacket in relation to those samples taken at greater distance from these structures (Figures 20 and 21). Sample 103, located just north of control area X, consists of calcareous shell hash which accounts for its higher Sr concentration. Sr is associated with $CaCO_3$ in the marine environment.

Sr was analysed because the element is concentrated in brines being discharged within the field (about 30 PPM). Table 6 shows the trace metal concentrations for a brine sample taken on platform B. Thus, the excess Sr measured in those samples taken near structures may reflect contamination due to brine discharge. The $CaCO_3$ concentration of a sample has to be taken into account when interpreting Sr data. Although Sr does not pose an obvious threat to the marine environment, it may prove to be a useful tracer for brine discharge and dispersion.

Enrichment of Co, Cr, Cu, Cd, Fe, Mn, and Ni in sediments taken from the study area is not evident. Although the exact source of heavy metal contaminants (Zn, Pb) within surface sediments of the study area is not known, the proximity of enriched sediments to platforms suggest that this contamination is related, either directly or indirectly, to drilling and/or production. However, contamination is localized to within only a few hundred feet of drilling platforms, probably because strong bottom currents disperse these materials quickly. It is too early to draw any conclusions regarding the specific source of Pb and Zn contaminants. On the other hand, it is reasonable to assume that the higher Ba content of samples collected near structures is due directly to drilling muds. Barite ($BaSO_4$) is used as the principal source of "weighting" material in drilling muds. During the drilling operation, cuttings and some waste water containing suspended muds are discharged overboard. Considering that Barite has a specific gravity of 4.5 and is practically insoluble in water, it is not surprising that sediment samples near the structures are enriched in Ba. The high Ba contents of samples #64 and #103 (figure 18) could also be the result of the dumping of drilling muds but there may be other explanations.

Suspended Sediment Investigation

Because the Buccaneer Oil Field lies only 50 Km south of Galveston Bay and in only 60 feet of water, several complexities are introduced into this study. Due to the proximity of the study area to Galveston Bay, the world's largest petrochemical complex, caution must be taken in establishing the extent of this and other outside influences upon the study area. This is difficult because we do not understand the mechanisms by which contaminated materials might be transported into the study area. In addition, the study area is situated in relatively shallow water where the influence of currents and waves may be considerable, especially during storms. The sandy nature of bottom sediments in the study area attests to the high energy bottom conditions which prevail there. The question of whether these processes are sufficiently great as to limit the deposition of contaminated materials is of serious concern. At present, sedimentologic data suggest that this is, in fact, the case.

It is well known that trace metals are readily absorbed by either clays or organic debris and will, therefore, be concentrated within very fine sedimentary material. Within the Buccaneer field area the bottom energy regime is sufficiently high as to maintain suspension of this material over much of the time. It is, therefore, highly likely that contaminants introduced into the sea by drilling and production will never reach the bottom.

Scuba divers working within the Buccaneer field frequently complain of extremely poor visibility at or near the bottom due to large amounts of suspended sediment. Our own observations using a Hydroproducts transmissiometer have substantiated the existence of large concentrations of suspended material at or near the bottom. These observations have introduced a new facet to the problem which must be dealt with before we can develop a sedimentologic and geochemical model for the Buccaneer Oil Field System.

In August of 1976 marine geologic investigations were expanded to include in situ measurement of suspended sediment and temperature and collection of large volume water samples for suspended sediment analysis. The objective of this aspect of the project was largely that of a feasibility study aimed at developing a system for measuring and sampling suspended sediment layers, obtaining some routine observations of bottom suspended sediment layers within the field and experimenting with various sedimentologic and geochemical analytical procedure for suspended sediments.

Suspended Sediments

Our measuring and sampling operation consists of a submersible pump, Hydroproducts Model 410-BR Transmissiometer and Industrial Instruments Model R55-2 salinometer-temperature probe mounted to a metal frame. The device is lowered through the water column slowly so that a continuous turbidity-temperature profile can be obtained. Large volume (approximately 5 gallon) water samples are pumped to the surface from those levels of the water column where increased turbidity is measured.

On those occasions when vessel time was not available, either because of heavy seas or mechanical problems, measurements and water samples were obtained directly from Platform B. Also, water clarity observations of sports divers and divers associated with this project were solicited. These observations greatly increased our total observation time.

Unfortunately our suspended sediment observations did not begin until late summer. On two occasions, once in late August and once in mid-September, bottom suspended sediment layers were observed. During our August cruise 3 water samples were collected from this layer both within and oustide the field. These samples contained sediment concentrations ranging from 10.0 mg/liter to 17.0 mg/liter. Trace metal concentrations and size analysis data for these samples are presented in Table 7 along with similar data for Galveston Bay samples.

The bottom suspended layer was also observed on our second cruise in mid-September. Problems with the water pump prevented us from acquiring any water samples at that time.

Cooling of the water column and mixing by storm waves since October has homogenized the water column such that the bottom suspended sediment layer was dissipated. Thus, by the time our measuring and sampling programs were perfected, the layer was gone. We hope to continue our monitoring of suspended sediments in the study area this summer and sedimentologic and geochemical analyses of these sediments.

Suspended sediment samples were also taken in Galveston Bay in order to determine the importance of this water body as a source of suspended sediments in the field area. Galveston Bay samples are labeled 10Y and 10Z and those from the field 8N, 8Q1 and 8Q2 in Table 7. Comparisons of trace metal data from the two sample sets show little correlation, but too few samples have been collected to draw any general conclusions at this time.

TRACE METALS IN ORGANISMS

The trace metal concentrations for those organisms analysed in this study are presented in Table 8. The average concentration and ranges of those elements analysed are presented along with selected BLM data in Table 9. Perhaps the most interesting results are those obtained from barnacles (Balanus) collected from the legs of the structures. These organisms appear to be concentrating Z , Sr and Cd. Because these organisms are filter feeders they would likely inject and concentrate effluents from the rigs. Additional analyses are needed to determine the extent of concentration of these elements and their source.

Fish taken from the study area contain minor amounts of Mn, Cu, Pb and Cd in their tissues. Concentration of Zn and occasionally Cr are higher than those of snapper analysed in the BLM project (Table 9). Also, fish livers show higher concentrations of Cu and Cr than do fish liver analyses performed by BLM workers.

Shrimp tissue samples analysed for this project show considerably less variation in trace metal concentrations than do barnacles and fish. Shrimp from the study area do contain substantially more Cu and Zn than do shrimp analysed by BLM researchers.

Only three plankton samples were received in sufficient quantity for trace metal analyses. These samples are all enriched in Cu, Zn, Cr and Pb with respect to BLM plankton analyses.

Although it is apparent that organisms taken from within the study area do contain abnormal concentrations of harmful trace elements, the source of this contamination is, as yet, unknown. More analyses are needed to determine the degree of contamination. Also, the source of these substances should be investigated during the next year.

Results and Discussion - Seismic Survey

The Buccaneer field is a typical Gulf Coast field producing from a trap created by a salt diapir. The formations above these domes are typically laced with faults and many are active today. As a result, seismic profiles over very recent sediments may show evidence of present day tectonic activity. Thus, faulting could raise some parts of the study area and depress others. This activity could, in part, be responsible for the sediment distribution pattern observed. In addition, these profiles might be expected to show the effects of Pleistocene Ice-Age activity on the shelf when sea level was approximately 170 meters lower than it is today. Thus, a surface exposed during sea level lowering would be expected to show stream channels characteristic of the rest of the Beaumont surface developed at that time. The interpretation objectives were then: to examine the section for possible signs of tectonic activity, and to look for channels defining the Beaumont surface.

Each seismic record was examined first for quality and depth of penetration. Key horizons were marked and identified from profile to profile (Fig. 22). Multiple reflections were identified visually and removed. Two key marker horizons were chosen in keeping with our interpretation objectives outlined earlier: one representative of the deepest structure consistently identifiable on the records -- "Deep Reflector"; the other was the shallowest continuous reflector identified - "Shallow Reflector". The Deep Reflector is approximately 165 feet below the sea floor, while the Shallow Reflector is approximately 10 feet below the sea floor. The interpretation was done by Ms. C. K. Watson.

The results are summarized in two maps (Figs. 23 and 24). The first is a contour map drawn on the Deep Reflector. Two features are apparent. First, the closed contours about the center of the dome indicate the continued influence of the salt dome diapiric structure. This uplift shows approximately 10 feet of structural relief over the area of the survey. This means that the dome uplift process was active after this bed was deposited and perhaps continues to be active at this time. If the age of the Deep Reflector were known, the rate of uplift could be calculated. In any case, the effect of the dome uplift is very near the surface. There is no apparent "Brite Spot" associated with this feature which indicates that there is not an accumulation of gas at this depth. The other significant feature of this map is a fault with a relief of approximately 6 feet. Sediments are displaced upward on the north. It could not really be called a growth fault since there appears to be no significant added section on the downthrown side.

The age of this horizon may be calculated if the rate of deposition is known. It is not. If a rate of 1 foot/ 1000 yrs. is assumed (30 cm/1000 yrs.), then the age is approximately 170,000 years. It should be clear that this sedimentation rate is assumed. The rate varies markedly over the Gulf shelf. This figure was taken from a paleomagnetic-paleostratigraphic study by Clark and Kennett (1973). Again, if the assumed sedimentation rate is correct and the dome began uplifting the Deep Reflector penecontemporaneously, the rate of uplift of the dome is approximately .053 feet/thousand years.

The second map shows little trace of the dome's tectonic activity. This map is drawn on the Shallow Reflector (Fig. 24). The two shallow closed contours in the center of the field correlate only approximately with those on the Deep Reflector and may or may not indicate active uplift. It is reasonable to expect, though, that the uplift would not be clearly visible at this horizon at the calculated rate of uplift. The shallowest feature on this horizon (at 8-10 feet below the sea floor) is that expected on the uplift side of the fault. Its presence indicates that the fault, even though not clear at this depth on the seismic record, must be a relatively recent feature. As such, it could exert an influence on the sediment distribution pattern.

In summary, the seismic measurements on the Buccaneer field area indicate that uplift and faulting may be active in the area today. If this is true, expected displacements are not significant in terms of engineering problems. The exception may be the apparent gas seep seen on profile 11. (Fig. 25) While these seeps are common in areas of active organic accumulation, few have been reported elsewhere. It is possible that this seep may be associated with a pipeline break. In any case, such a seep represents a definite hazard to production activities. The procedure used was adequate for the research objectives of the project. That is, a close survey grid using a seismic instrument with high resolution and 150 to 200 feet depth of penetration may determine the extent of present day tectonic activity. Additional work recommended might include detailed profiling with a higher frequency source. A higher resolution instrument would reveal deformation in the shallowest layers.

Results and Discussion - Magnetic Survey

The magnetic survey objective was to locate pipelines in the Buccaneer oil field in order to determine the areas of safe coring operations. The profiles were first interpreted and then the anomalies picked were compared with the original pipeline map provided by Shell Oil Company. The principal problem encountered in the interpretation was the separation of magnetic signature of the pipelines from that of the platforms they were associated with. This became most difficult in the area nearest the platforms.

The pipeline map was then redrawn on the basis of the anomalies and the Lorac positioning (Fig. 26). The redrawn pipeline locations agree basically with the original map, but each is apparently displaced. The extent of this displacement ranges from a few tens of meters to more than 100 meters. The pipelines appear to be systematically displaced to the northwest. A simple calculation, based on a line source of magnetization, allows the size of the pipeline to be calculated (Table 10). The calculated sizes agree remarkably well with the sizes described on the original map. Thus, a magnetic survey may be used, both to find and estimate the sizes of a buried pipeline.

It is evident from the magnetic survey that many of the pipelines have been systematically displaced from their original positions. This means that the pipeline map of this field is invalid. Perhaps this also means that a periodic revalidation of pipeline maps for all offshore oil fields is in order. The Captain of the Gus III, Jim McMurray, indicates that fishermen are generally aware of the situation and avoid the bottom where pipelines are known where possible. It is possible that any seafloor or near-seafloor activity may encounter these pipelines. Again, this may be the case for a number of offshore oilfields, and perhaps pipeline exposure should be assessed and activities endangering them should be controlled.

Results and Discussion - Sidescan Sonar Survey

The survey was interpreted in the field and track lines (Fig. 3) were adjusted as new objectives became apparent. Our first run was in the area of the major platforms. Fig. 10 shows the platform legs and lower supports clearly. Winnowing about the platform legs is not apparent from these records,however, sedimentary evidence suggest that sedimentation within a few hundred feet of the rig is influenced by the structure. Note also that several pipelines are visible. Preliminary interpretation suggests that they are resting on the seafloor, but suspension with winnowing beneath by bottom currents cannot be ruled out. Also, we suspect that these pipelines may act as dams to sediments swept against them.

The second part of the survey involved a search of the northeast section of the Buccaneer test area. Here we found no evidence of significant bottom relief. This is discussed in detail in the sediment section.

Multivariate Numerical Analysis of the Sedimentary Size Parameters

A. Redundancy of variables

The sedimentary size parameters measured in this study were the weight % of the following:

1. the individual sand size fraction in 1/40 intervals from -1.00 to 4.00 (21 parameters)
2. the total sand size fraction (this is simply the sum of the 0 intervals)
3. the silt size fraction (1 parameter)
4. the clay size fraction (1 parameter)

All 23 parameters were measured on 85 sediment samples (the weight % of total sand, silt and clay fractions were measured on additional 22 samples). Sedimentary size parameters are reported in Table 1. Table 11 shows the summary statistics for the 85 samples. Note that the coefficient of variation of all 23 variables is greater than the expected analytical error which is estimated to be about ±20% at a confidence level of 95%. Thus, all the sediment size parameters are significant and show a greater variation than would be expected from analytical error only.

B. Establishment of an objective surface sediment facies map of the study area based on the 23 sediment size parameters.

The 85 sediment samples are compared to each other on the basis of the 23 sediment size parameters using Q-mode cluster analysis. The Sorenson* similiarity coefficient is used to generate a hierarchical classification of the samples which is displayed in a Q-mode (comparing samples to samples) dendrogram, Figure 27.

* This similarity coefficient is distribution independent and therefore ideally suited for this study.

In the dendrogram the samples that are connected with vertical lines to the far left are most similar while vertical lines to the far right connect samples or groups of samples which show much less similarity. Thus, Figure 27 shows what samples behave similarly and the level of that similarity. For example, samples 80 and 82 behave very similar to each other but behave less similar to sample 77 and considerably different than sample 43. (These samples are indicated by arrows in Figure 27). The vertical axis has no meaning other than as an ordered list of samples arbitrarily spaced. The following conclusions can be drawn from the dendrogram:

1. The samples can be placed into three major groups (labeled Group 1, 2 and 3 on Figure 27). Some samples (labeled "Texturally Anomalous") do not appear to be similar to each other or to samples in the three major groups (e.g. samples 85, 81, 102, 104, etc.)

2. The majority of the field samples are in Groups 1, 2, or 3. A large percentage of the platform samples are in the "texturally anomalous" group and most of these are the samples collected closest to the structures. As pointed out earlier in the section on Sedimentology samples taken close to the platforms show considerable variation.

3. Group 2 can be further subdivided into three subgroups A, B, and C.

Table 12 gives the mean sedimentary size parameters for the natural groups defined on the Q-mode dendrogram (i.e. Group 1, Group 2A, Group 2B, Group 2C and Group 3). The five group means are plotted on a sand/silt/clay diagram (figure 28) for comparison with Figure 6 which shows individual samples. Table 13 gives the summary statistics of the five groups so that one may see the range of variation within each group.

These five groups define five natural sedimentary facies. The geographic distribution of the five facies is shown in figure 29 along with those samples classified as "texturally anomalous". Note the similarity between this diagram and Figure 7.

C. An objective classification of the sedimentary size parameters.

The 23 sedimentary size parameters measured on each of the 85 samples are compared to each other using the Sorenson similarity coefficient and are displayed in a hierarchial classification called a R-mode (comparing variables to variables) dendrogram, Figure 30. This dendrogram is interpreted in exactly the same way as Figure 27. Thus, the 3.250 and 3.500 size functions behave very similar to each other but less similar to 3.750 and considerably different than 1.750. The behavior of the various sedimentary size fractions is a function of (1) the hydraulics of the environment in which they were deposited and (2) the original size distribution of the material of the source area which contributed the sediments.

In the near future the geochemical data will be clustered with the sediment size parameters. The Q-mode dendrogram will define an objective classification of samples based on geochemical as well as sedimentological parameters. This is a very important step because the trace metals are believed to be associated with the finer sediments (clays and organic material) and because there is considerable variation in sediment size throughout the study area. The R-mode dendrogram will define an objective classification of the variables themselves which will enable one to establish trace metal coherence patterns and coherence patterns between trace metals and sediment size. Parameters measured in this study by other investigators (e.g. organic carbon, carbon isotopes) will be integrated with our data to develop the most comprehensive model of the study area.

LITERATURE CITED

Cattell, R. B., 1965a, Factor analysis: An introduction to essentials, I. The purpose and underlying models: Biometrics, v. 21, p. 190-215.

Cattell, R. B., 1965b, Factor analysis: An introduction to essentials, II. The role of factor analysis in research: Biometrics, v. 21, p. 405-435.

Clark, H. C. and Kennett, J. P., 1973, Paleomagnetic excursion recorded in latest Pleistocene deep sea sediments, Gulf of Mexico: Earth and Planteary Science Letters, v. 19, p. 267-274.

Cole, A. J. (ed.) 1969, Numerical Taxonomy: Academic Press, London and New York, p. 1-324.

Gevirtz, J. L., Park, R. A., and Friedman, G. M., 1971, Paleoecology of benthonic foraminifera and associated microorganisms of the continental shelf off Long Island, New York: J. of Paleontol., v. 45, p. 153-177.

Gevirtz, J. L. and Schwarzer, R. R., 1976, Objective classification of discrete sedimentary size-frequency distributions. Geol. Soc. Am. Abstr. with Programs, South Central Section.

Harmon, H., 1967, Modern Factor Analysis: Univ. of Chicago Press, Chicago, p. 1-474.

Heezen, B. C., and C. D. Hollister, 1964, Deep-sea current evidence from abyssal sediments: Marine Geology, v. 1, p. 141-174.

Orloci, L., 1969, Information-theory models for hierarchic and non-hierarchic classification. In: Cole, A. J. (ed.), Numerical Taxonomy, p. 149-164, Academic Press, London and New York.

Schwarzer, R. R., 1973, Major element variation in alkaline olivine basalts. Geol. Soc. Am. Abstr. with Programs 5, 799.

Scrudato, R. J., 1976, Sediments and geochemistry III in A Preliminary Assessment of the Buccaneer Oil/Gas Field (Pilot Report). Gulf Fisheries Center, Galveston, Texas, p. 26-43.

Shepard, F. P., 1954, Nomenclature based on sand-silt-clay ratios: Jour. Sed. Petrology, v. 24, p. 151-158.

Taber, E., 1971, Clay Diagenesis and Holocene Sediments of Galveston Bay and the Adjacent Continental Shelf, Unpublished Masters Thesis, University of Houston, 74 p.

Van Andel, T. H., and D. M. Poole, 1960, Sources of Recent sediments in the northern Gulf of Mexico: Jour. Sed. Petrology, v. 30, p. 91-122.

APPENDIX

TABLE 1

Sedimentology & Mineralogy
A. Field Stations (see Figure 2.3-4 for location)

	Sediment size parameters			Heavy Minerals	Clay Mineralogy		
Station #	Wt. % Sand	Wt. % Silt	Wt. % Clay	Wt. %	Wt. % Expandables	Wt. % Illite	Wt. % Kaolinite
11	59.33	27.62	13.05				
13	49.35	28.87	21.78				
21	69.26	17.39	13.35	0.14%			
31	53.10	20.64	26.26				
32	73.87	8.86	17.27				
38	71.47	20.61	7.92				
39	66.85	20.64	12.51				
40	58.78	37.10	4.12	0.24%	57%	29%	14%
61	76.09	23.91	0.00				
62	66.99	26.05	6.96				
63	75.96	22.48	1.56		62%	28%	10%
64	96.49	3.51	0.00				
65	98.92	1.08	0.00				
66	95.43	4.57	0.00				
67	55.92	22.19	21.88		49%	37%	14%
69	46.84	37.75	15.41	0.21%	69%	21%	10%
70	55.21	23.52	21.27				
71	41.49	34.56	23.95	0.39%	60%	31%	9%
73	80.22	13.61	6.17		57%	27%	16%
74	74.88	10.91	14.21				
76	70.82	8.55	20.63		55%	32%	13%
77	70.38	9.59	20.03				
78	68.33	21.21	10.45		65%	25%	10%
80	74.82	15.71	9.46				
81	76.50	22.01	1.49				
82	70.70	16.56	12.73		50%	36%	14%
83	77.98	22.02	0.00				
84	71.98	13.33	14.69				
85	74.51	12.18	13.32				
86	75.04	17.49	7.47				
87	71.26	15.94	12.80	0.15%	57%	32%	11%
89	67.17	20.83	12.00				
92	72.06	11.69	16.25				
93	62.91	22.39	14.70				
94	60.20			0.20%			
96	53.15	19.33	27.52		56%	31%	13%

TABLE 1 (continued)

Sedimentology & Mineralogy
A. Field Stations (see Figure 2.3-4 for location)

Station #	Sediment size parameters Wt. % Sand	Wt. % Silt	Wt. % Clay	Heavy Minerals Wt. %	Clay Mineralogy Wt. % Expandables	Wt. % Illite	Wt. % Kaolinite
97	54.63	37.48	7.89				
98	54.25	30.39	15.36				
99	56.42	22.27	21.31				
100	56.78	24.90	18.32	0.44%			
101	60.28	18.39	21.33		58%	33%	9%
102	21.27	37.54	41.19		68%	20%	12%
103	99.04	0.93	0.00				
104	13.69	61.35	24.96				
105	65.53	20.32	14.26	0.47%			
107	68.17	19.71	12.11				
108	74.05	18.13	7.82				
110	71.51	14.34	14.15				
A	8.43	44.61	46.95				
B	11.07	21.30	67.62				
C	20.82	39.67	39.50				
D	15.04	41.64	43.13				
E	44.21	30.61	25.18				
F	79.50	10.90	9.60				
G	63.57	20.49	15.94				
H	67.05	17.13	15.82				
I	78.97	10.07	10.96				
13	66.9	12.3	20.7				
16	35.0	38.4	26.5				
20	72.1	15.3	12.7				
24	68.8	18.3	12.7				
28	72.5	16.7	21.6				

TABLE 1

Sedimentology & Mineralogy
B. Stations taken within 375 feet of Platform A & B & near well jacket (see figure 2.3-5 for locations)

	Sediment size parameters			Heavy Minerals	Clay Mineralogy		
Station #	Wt. % Sand	Wt. % Silt	Wt. % Clay	Wt. %	Wt. % Expandables	Wt. % Illite	Wt. % Kaolinite
2	68.58	14.25	17.17				
3	55.00	19.66	25.34				
4	57.14	20.10	22.76				
5	87.3	7.6	5.2				
6	42.39	50.83	6.78		63%	27%	10%
9	68.76	9.64	21.60				
10	61.37	16.83	21.80				
11	53.60	13.82	32.58		30%	50%	20%
14	67.83	13.70	18.47				
15	55.50	12.48	32.02				
16	73.7	16.1	9.8				
17	72.36	11.34	16.30		52%	34%	12%
18	63.19	18.14	18.67		42%	46%	12%
19	71.8	14.3	13.7				
20	60.4	22.2	17.8				
21	69.3	16.4	13.6		67%	25%	11%
23	72.3	17.9	10.1				
24	65.8	20.3	13.7				
25	72.5	16.7	21.6				
26	65.0	20.8	14.2				
27	68.9	16.8	14.2				
28	62.6	22.1	14.9				
29	43.4	30.8	25.9				
30	65.5	14.8	19.2				
33	71.88	6.95	21.19		73%	17%	10%
34	80.75	7.38	11.87				
35	71.13	11.04	17.83		47%	37%	16%
36	86.94	2.78	10.28				
37	83.84	5.16	10.99		62%	29%	9%
38	65.26	15.64	19.10				
42	87.48	3.63	8.89		59%	31%	10%
43	87.03	4.05	8.92		43%	43%	14%

TABLE 1

Sedimentology & Mineralogy

b. Stations taken within 375 feet of Platform A & B & near well jacket (see figure 2.3-5 for locations)

	Sediment size parameters			Heavy Minerals	Clay Mineralogy		
Station #	Wt. % Sand	Wt. % Silt	Wt. % Clay	Wt. %	Wt. % Expandables	Wt. % Illite	Wt. % Kaolinite
44	63.12	15.75	21.23		43%	43%	14%
45	80.96	6.02	13.01				
46	68.92	13.77	17.31		55%	32%	13%
47	75.85	6.73	17.42				
48	80.98	7.18	11.84		72%	20%	8%
49	79.15	6.29	14.55				
50	90.80	1.65	7.28				
51	92.07	1.06	6.27				

TABLE 2 CLAY MINERALOGY OF SELECTED SEDIMENT SAMPLES

The clay mineralogy of selected surface sediment samples from Buccaneer Field stations (see Figure 12 for location) and from stations within 375 ft. of Platforms A and B and Well Jacket (see Figure 13 for locations) is presented in this table. The clay mineralogy is reported as the weight percent of Expandable Clays (primarily montmorillonite), Illite, and Kaolinite. The other minerals present in the clay size fraction are quartz (Q), feldspar (F) and calcite (C). Sharpness of the expandable clays (001) reflection is a measure of the "crystallinity" of these phases. The sharper the reflection the more crystalline the phase ("B" for broad reflection, "S" for sharp reflection, and "S^{-}" for a sharp reflection but not as sharp as "S"). See Figure for sample X-ray diffraction patterns showing sharp (S) and broad (B) expandable clays (001) reflections.

Field Stations Sample #	Expandable Clays	Illite	Kaolinite	Sharpness of expandable clays (001) reflection	Other minerals present
40	57%	29%	14%	B	Q
63	62%	28%	10%	B	Q, F
67	49%	37%	14%	B	Q
69'	69%	21%	10%	B	Q
71	60%	31%	9%	B	Q
73	57%	27%	16%	B	Q
76'	55%	32%	13%	S	Q
78	65%	25%	10%	B	Q
82	50%	36%	14%	B	Q
87	57%	32%	11%	B	Q
96	56%	31%	13%	B	Q
101	58%	33%	9%	B	Q
102	68%	20%	12%	B	Q
A	51%	34%	15%	B	Q
D	59%	29%	12%	B	Q

Table 2 (continued)

Samples Collected within 375' of platforms A & B and Well Jacket Sample #	Expandable Clays	Illite	Kaolinite	Sharpness of expandable clays (001) reflection	Other minerals present
6	63%	27%	10%	B	Q
11	30%	50%	20%	B	Q
13	49%	39%	12%	S-	Q
17	52%	34%	12%	S	Q
18	42%	46%	12%	S-	Q
21	67%	25%	11%	B	Q
32	47%	38%	15%	B	Q
33	73%	17%	10%	S	Q
35	47%	37%	16%	B	Q
37	62%	29%	9%	B	Q,F
42	59%	31%	10%	B	Q
43	43%	43%	14%	S	Q
44	43%	43%	14%	S-	Q,C,
46	55%	32%	13%	S	Q
48	72%	20%	8%	S	Q

Table 3 Trace Metal Data for Field Sediment Stations

The concentration of trace metals (in ppm) for surface sediment samples and a few down core samples from the Buccaneer Field are reported. See Figure 3 for sample locations. Down core samples are designated by sample number and the depth in the core at which the sample was taken. Some of these samples were used by Dr. E. W. Behrens (Work Unit 2.4.3) for determination of total organic carbon (in Wt. %) and this data is reported here also. Clay mineralogy was determined on samples designated by an *.

Field Stations	Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	Zn	% org carbon	Clay Mineralogy
11	n.d.	0.8	n.d.	4.5	3.8	4200	152.5	20.0	12.0	44.0	37.3	0.38	
11-5"	125	0.8	19.3	9.8	6.3	8075	200.5	22.5	12.3	12.3	43.8		
13	n.d.	0.8	n.d.	4.3	3.8								
21	n.d.	1.0	n.d.	6.0	2.5	5500	132.5	22.5	8.3	20.8	38.3	0.20	
31	225	1.5	22.0	8.5	4.5	4525	162.3	31.8	16.8	211.3	39.0	0.60	
32	n.d.	1.5	n.d.	6.8	3.3	4550	123.3	25.0	13.0	153.0	39.5	0.28	
38	n.d.	1.0	n.d.	4.5	3.0	5550	138.3	25.0	11.3	57.8	40.5	0.35	
39	200	1.5	19.7	5.5	4.5	6025	157.8	25.0	11.3	52.0	44.8	0.29	
40	50	1.3	18.1	5.5	4.5	5825	164.3	27.5	13.5	43.3	49.3	0.38	*
61	75	1.3	16.8	5.8	2.3	3400	123.5	25.0	9.8	24.0	33.8	0.31	
62	75	1.3	18.8	4.8	2.5	4150	180.8	27.5	18.8	43.3	n.d.	0.40	
62(4-6")	100	1.3	15.5	6.0	3.5	5075	134.3	30.0	11.0	59.3	39.0		
63	175	1.3	16.8	5.5	2.8	3600	130.0	27.5	12.0	60.3	38.3	0.29	*
64	1650	3.5	34.5	31.8	8.0	6575	397.8	62.5	53.8	1052.5	25.5		
65	175	1.5	17.4	8.3	2.5	3625	150.3	32.5	14.8	259.3	34.5		
67	100	1.5	15.5	11.8	5.5	3850	132.5	30.0	12.8	9.5			*
67'	125	1.2	20.3	10.0	4.8	7400	142.0	32.5	11.3	14.0	61.0		
69	150	1.0	16.3	6.3	4.5	4825	130.3	27.5	12.3	15.8	42.3	0.41	
69'	150	1.0	16.1	10.3	4.5	7150	141.8	27.5	12.0		49.3	0.41	*
70	250	1.3	19.3	7.3	7.0	6300	182.3	35.0	13.5	34.5	51.3		
71	<50	1.3	16.9	5.8	4.8	5325	162.8	30.0	14.5	18.3	45.8	0.54	*
73	<50	1.0	15.7	4.3	4.3	4125	134.3	30.0	12.8	58.3	41.5	0.34	*
74	<50	1.0	17.0	4.8	3.5	3950	117.0	30.0	11.8	21.5	39.8	0.28	
76	<50	1.0	15.1	5.5	3.8	4375	120.5	27.5	10.0	13.0	42.0	0.34/0.36	*
77	50	1.0	16.1	5.5	4.3	4775	123.5	27.5	9.3	14.3	42.0	0.15	
78	200	1.0	18.1	5.5	5.0	4525	123.8	27.5	9.8	47.8	44.3	0.32	*
80	<50	1.0	16.1	5.7	4.0	4450	122.8	27.5	10.5	18.5	40.0	0.32	
81	150	1.3	17.3	6.2	4.5	3975	139.0	32.5	12.3	76.3	40.3	0.33	
82	150	1.3	15.0	7.2	4.8	5550	156.8	30.0	11.3	22.3	49.3	0.34	*
83	50	1.3	20.7	6.0	5.5	3800	118	32.5	11.3	54.0	44.3	0.25	
84	50	1.3	15.4	4.2	4.5	4725	134.5	30.0	12.0	64.3	37.0	0.45/0.21	

TABLE 3 (continued)

Field Stations	Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	Zn	% org carbon	Clay Mineralogy
85	275	1.0	14.7	4.3	4.3	3700	112.3	27.5	11.8	27.5	38.0	0.30	
86	325	1.3	19.5	7.0	5.3	3450	109.8	32.5	13.5	161.8	37.5	0.30	
87	200	1.0	16.7	5.0	5.3	3800	133.0	30.0	12.3	91.8	37.8	0.28	
89	<50	1.0	17.6	5.5	5.8	4875	148.3	27.5	10.0	28.3	36.0	0.21	
89'	50	1.0	15.9	6.8	4.0	4500	118.0	27.5	9.5	18.8	39.5	0.21	
92	50	1.0	13.0	4.5	2.8	3025	153.5	27.5	10.3	26.5	34.5	0.10	
92'	125	1.0	12.0	5.8	3.3	4450	127.3	27.5	10.3	24.0	39.8	0.10	
93	175	1.3	17.5	5.8	5.3	4675	208.5	32.5	14.3	93.3	42.3		
94	175	1.3	17.4	4.3	4.5	4275	156.5	32.5	11.5	49.8	39.5	0.36	
96	250	1.0	18.7	5.3	4.5	3600	135.5	35.0	11.5	97.8	35.5	0.42	*
97	150	1.3	18.1	4.8	5.5	4325	162.5	35.0	14.3	66.0	39.5	0.39	
98	75	1.0	15.9	5.5	5.5	5950	169.8	32.5	12.5	22.5	46.8	0.79	
99	50	1.8	12.9	4.0	3.8	3600	125.3	30.0	9.8	26.8	34.3	0.23	
100	200	1.3	18.3	4.5	4.5	3625	145.5	27.5	11.8	57.3	34.8	0.39	
101	450	1.8	24.5	8.0	6.3	6475	222.3	42.5	16.5	99.5	48.0		*
101-6"	125	1.3	19.0	19.8	19.5	2500	264.8	47.5	21.5	4.0	89.3		
102	100	1.3	16.2	6.8	7.0	6350	255.8	35.0	14.3	22.3	47.8	0.18	*
102-12"	50	1.3	27.0	15.5	11.8	1260	455.3	37.4	23.5	2.0	35.0	0.70	
103	1000	3.3	29.0	33.0	9.3	4925	387.0	65.0	46.8	1005.0	17.5	4.97	
104	225	1.5	17.8	6.0	6.3	5450	345.3	35.0	14.5	98.5	41.3	0.52	
105	425	1.5	22.7	7.5	5.5	4450	252.8	27.5	15.3	203.8	42.0	0.48	
107	125	1.3	23.4	5.5	4.3	4250	145.8	22.5	10.50	24.5	39.8	0.26	
108	75	1.0	20.2	6.0	3.5	3950	146.3	25.0	11.0	25.0	43.2		
108'	150	1.0	16.9	9.3	3.3	5375	138.8	20.0	9.5	10.5	38.3		
A	400	1.3	20.3	12.5	9.5	10350	496.8	30.0	19.0	22.0	66.3		
B	75	1.3	15.8	14.5	13.5	12900	453.8	35.0	22.3	6.8	58.2		
C	100	1.3	26.9	11.0	8.3	10175	255.8	30.0	15.8	7.0	74.3		
D	100	1.3	22.8	9.5	8.5	9200	223.0	30.0	16.8	9.3	69.0		
E	100	1.3	23.5	10.8	6.3	7300	187.0	30.0	14.8	11.5	60.3		
F	75	1.0	18.9	5.8	3.3	3825	144.0	27.5	9.5	49.8	35.3		
G	24	1.5	23.0	9.3	5.3	4400	147.5	32.5	14.8	210.5	38.3		
H	n.d.	1.5		7.50	5.0	4300	177.0	30.0	11.5	135.0	41.5		
I	300	1.3		7.3	4.0	3825	119.0	27.5	14.8	110.0	76.8		
J	n.d.	1.3		6.3	4.0	3450	120.0	25.0	11.8	59.8	37.5		
110	<50			5.8	4.5			25.0	13.8		42.8	3.70	

TABLE 4

Trace Metal Data for Sediment Stations Taken within 375 ft. of Platform A and B and near Well Jacket

The concentration of trace metals (in ppm) for surface sediment samples taken within 375 ft. of platform A and B and near well jacket in the Buccaneer Field are reported. See Figure 5 for sample locations. Some of these samples were used by Dr. E. W. Behrens (Work Unit 2.4.3) for determination of total organic carbon (in Wt. %) and this data is reported here also. Clay mineralogy was determined on samples designated by an *.

Stations	Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	Zn	% org carbon	Clay Mineralogy
2	50	1.0	n.d.	8.8	4.8	3350	143.3	22.5	11.8	68.3	39.5		
3	100	1.3	20.1	8.8	4.0	2950	145.8	22.5	12.3	44.3	34.7		
5	500	1.8	n.d.	31.0	8.8	6175	156.0	30.0	42.3	256.3	n.d.		
6	225	1.3	18.6	18.0	18.5	3750	208.5	37.5	36.3	14.2	85.0		*
9	250	1.3	14.5	7.5	4.3	3225	128.0	22.5	11.3	92.8	35.3		
10	400	1.5	21.6	8.0	5.0	3450	129.8	25.0	12.3	99.0	37.0		
11	375	1.3	18.0	7.0	4.0	1300	138.5	22.5	16.0	95.3	68.3		*
13	600	2.0	27.5	8.3	8.0	6400	230.3	35.0	20.8	316.8	67.5		*
14	275	1.5	23.1	5.3	4.5	3825	154.3	25.0	12.5	79.5	41.0		
15	150	1.5	22.2	4.8	4.5	3900	134.3	20.0	12.5	104.0	40.5		
16	550	1.8	26.4	5.8	6.0	4700	172.5	30.0	39.5	205.3	46.3		
17	550	2.0	23.0	8.0	9.5	13250	218.5	32.5	22.0	113.5	135.0		*
18	325	1.3	23.5	7.5	5.0	6250	176.5	22.5	52.8	70.8	57.5		
19	450	1.2	18.2	4.8	6.3	5300	187.3	25.0	16.0	87.5	48.8		
20	325	1.2	22.3	5.0	5.0	5700	211.5	22.5	12.8	39.0	46.5		
21	200	1.5	21.4	7.0	5.5	1450	199.0	25.0	13.8	63.8	48.8		*
23	500	1.2	21.7	7.5	4.8	5250	215.0	25.0	39.5	86.0	52.8		
24	400	1.5	19.6	4.8	5.3	5575	238.3	22.5	14.5	48.8	53.8		
25	575	1.5	21.3	8.3	5.0	5475	200.3	27.5	14.0	89.0	46.0		
26	500	1.5	13.2	6.5	5.8	6300	164.3	22.5	27.5	38.3	70.0		
27	875	1.8	6.3	7.5	11.0	9975	286.8	30.0	37.3	238.8	131.6		
28	725	1.5	23.1	7.5	5.0	4800	183.3	25.0	13.0	157.5	40.8		
29	300	1.5	17.9	7.5	5.8	6825	192.3	25.0	13.0	18.3	51.8		
30	550	1.8	27.8	5.3	4.3	4200	208.8	25.0	13.3	148.8	36.3		
32	325	1.5	13.9	5.3	4.5	6700	197.8	25.0	17.3	51.0	66.5		*
33	350	1.8	15.2	4.8	6.0	5050	143.5	27.5	21.8	107.3	62.5		*
34	950	2.5	n.d.	15.8	8.00	5000	125.8	30.0	97.0	312.2	n.d.		

Table 4 (continued)

Rig Stations	Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	Zn	% org carbon	Clay Mineralogy
35	125	1.5	17.7	6.0	6.8	5775	163.8	25.0	13.5	21.8	62.3		*
36	350	2.0	22.2	7.0	5.8	2925	104.5	27.5	15.5	214.5	58.0		
37	400	1.8	17.4	2.3	3.3	3150	119.0	22.5	17.3	89.8	48.3	0.16	*
38	125	1.8	20.6	4.3	4.0	4500	127.5	25.0	9.5	42.0	44.8	0.21	
42	200	1.8	21.5	4.0	4.0	3150	107.8	25.0	12.3	220.5	33.5	0.21	*
43	675	1.8	15.3	17.0	4.0	3150	114.5	25.0	13.3	205.5	37.3	0.15	*
44	200	1.8	20.5	4.0	4.8	4800	134.8	22.5	10.3	36.3	49.5	0.31	*
45	700	2.0	n.d.	14.0	6.3	4075	130.8	27.5	21.5	303.8	n.d.		
46	300	1.3	17.8	7.3	3.8	3725	121.8	22.5	10.0	78.35	51.5		*
48	125	1.5	19.7	7.0	3.8	4600	139.0	22.5	8.8	30.5	45.3	0.11	*
48b	275	1.3	24.0	7.8	3.5	3775	119.8	22.5	10.3	51.8	42.3		
49	150	1.3	16.0	17.3	4.8	2625	122.3	22.5	10.8	75.0	33.5		
50	700	2.0	20.8	8.0	7.3	2800	118.8	30.0	37.8	258.5	59.0	0.25	
51	175	1.3	18.1	11.8	3.3	2450	111.0	22.5	16.5	51.3	68.0		

TABLE 5 Comparison of Trace Metal Concentrations from the Buccaneer Field Study with BLM's South Texas Outer Continental Shelf Study. The arithmetic mean ($\bar{X}$) and the coefficient of variation (V) of the trace metal concentrations in surface sediments from the Buccaneer Field Study and the BLM South Texas Outer Continental Shelf Study are reported in this table. The Buccaneer data is divided into field stations and station collected within 375 feet of platform A & B and well jacket.

	BLM, South Texas Outer Continental Shelf Study[1]		Buccaneer Field Stations[2]		Stations taken within 375 feet of Platform A & B and Well Jacket (Buccaneer Field)[3]	
Element	$\bar{X}$	V[4]	$\bar{X}$	V	$\bar{X}$	V
Ba	101.3	52%	144.0	%	355.6	50%
Cd	0.6	40%	1.3	32%	1.6	16%
Cu	6.5	25%	4.8	35%	5.4	48%
Cr	22.3	24%	6.7	72%	7.4	48%
Fe	21869.4	15%	4733.6	34%	4668.1	47%
Mn	362.6	25%	164.1	46%	160.6	25%
Ni	16.9	26%	30.4	22%	25.2	15%
Pb	8.9	27%	13.2	47%	18.1	58%
Zn	62.9	18%	39.9		53.0	35%
Sr	these elements not determined in BLM study		76.8	211%	98.5	74%
Co					20.2	18%

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1 Data from BLM Environmental Assessment of the South Texas Outer Continental Shelf, Geologic Investigations, Oct. 25, 1974 to Dec. 1, 1975, Table 17, p. 206.

2 Data from Table 3

3 Date from Table 4

4 Coefficient of Variation is the standard deviation divided by the mean and multiplied by 100 ($V = 100 \frac{s}{\bar{x}}$).

Table 7. Suspended Sediments

The concentration of suspended sediments (in mg/l), the trace metal concentration (in ppm), and the mean grain size (in Ø units) is given for suspended sediments collected in Galveston Bay (labeled G) and in Buccaneer Field (labeled B). Note that sediment size and geochemistry could not be made for samples with a suspended sediment concentration less than 7.0 mg/liter.

Sample #	Concentration (mg/l)	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn	Mean Sediment Size	Date Collected
G-10Y	6.9	2.6	9.3	112.8	90.7	181.4	70.5	46.3	120.9	4.3Ø	10/5/76
G-10Z	7.1	4.7	9.0	142.6	60.5	556.6	46.9	43.0	416.0	4.9Ø	10/5/76
B-8-3	<1.0										8/4/76
B-8-B	<1.0										8/4/76
B-8-J	<1.0										8/4/76
B-8-K	<1.0										8/5/76
B-8L1	<1.0										8/5/76
B-8L2	1.2										8/5/76
B-8-M	<1.0										8/6/76
B-8-N	10.0	<1	6.5	74.1	19.2	735.9	34.3	35.7	65.9	6.2Ø	8/6/76
B-8-P	3.2										8/6/76
B-8Q1	10.0	1.7	5.7	33.1	124.2	186.3	51.1	30.4	140.8	6.0Ø	9/13/76
B-8Q2	17.0	1.5	6.1	25.2	85.4	252.8	36.6	26.0	95.9	5.2Ø	9/13/76
B-8X	2.4										9/13/76
B-11A	<1.0										10/28/76
B-11B	<1.0										10/28/76
B-11C	<1.0										11/15/76
B-11D	<1.0										11/15/76
B-11E	<1.0										12/1/76

Table 7 (Continued)

Sample #	Concentration (mg/l)	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn	Mean Sediment Size	Date Collected
B-11G	<1.0										12/1/76
B-11H	<1.0										12/1/76
B-11H'	<1.0										1/5/77
B-11I	<1.0										3/15/77
B-11J	<1.0										3/15/77

Table 8 Trace Metals in Organisms (Concentration in ppm) Barnacles (Balanus)

Sample Number	Location	Depth (ft)	Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	Zn
B1	Jacket C	0		24.5	N.d.	1	21.8	480.0	18.5	N.d.	9.5	24.8	195.8
2	L	0		23.5	N.d.	1	26.8	367.5	15.5	N.d.	8.5	47.5	240.5
3	0	30		14.5	1.0	1	15.5	205.0	11.0	1.0	7.0	27.0	185.5
4	A	0		24.0	1.0	1	20.5	195.0	8.5	1	5.5	38.8	198.8
5	O	00		17.8	2.8	1	16.8	175.0	12.8	4.3	7.0	43.5	181.0
6	C	30		23.0	3.0	1	20.0	600.0	12.0	5.5	10.0	49.0	281.0
7	L	30		17.0	1.0	1	15.5	210.0	8.5	1	9.0	25.0	240.0
8	G	30		21.5	4.0	1	24.0	340.0	10.5	9.0	11.0	51.5	269.5
9	G	0		20.5	1.5	1	12.5	415.0	6.5	2.5	10.0	28.0	166.5
10	H	0		19.0	3.5	1	16.5	205.0	8.5	6.0	11.5	36.5	151.5
11	H	30		20.8	4.5	1	16.5	405.0	10.8	9.5	9.8	43.8	196.0
12	D	0		19.5	5.0	1	17.0	207.5	7.5	16.3	10.3	22.8	160.0
13	K	0		20.5	3.5	1	12.8	252.5	9.5	10.0	9.3	24.0	126.5
14	K	30		15.5	5.0	1	14.5	195.0	9.8	15.5	10.3	25.3	161.0
15	D	30		31.0	3.3	1	14.0	212.5	8.0	4.5	6.5	20.5	174.0
16	I	30		22.0	1.5	1	20.0	270.0	9.5	5.0	9.5	74.0	215.5
17	I	0		24.0	1.0	1	18.5	155.0	5.5	7.5	5.5	42.5	170.5
18	F	30		19.5	2.0	1	20.0	245.0	10.0	7.3	10.0	43.0	265.0
19	F	0		25.0	1.5	1	16.0	130.0	10.0	2.3	6.0	45.0	188.5
20	A	30		17.0	3.5	1	13.0	180.0	9.5	3.5	9.0	38.0	212.5
21	A	40		11.5	5.0	11.3	23.8	345.0	16.0	8.0	6.0	99.8	209.8
22	0	45		17.8	4.8	64.3	20.0	322.5	11.5	8.0	5.5	53.3	219.0
23	I	40		16.5	4.5	1	18.5	302.5	8.5	10.0	3.5	35.3	193.8
24	K	30		16.0	5.3	1	18.3	497.5	12.8	12.5	3.5	90.8	212.0
25	N	25		11.0	2.8	1	17.0	335.0	9.8	2.5	5.0	46.0	202.3
26	N	50		17.3	5.5	1	27.8	505.0	13.2	15.0	6.0	88.8	217.3
27	M	50		11.0	4.0	1	13.8	400.0	13.8	12.5	5.8	38.5	206.3
28	M	25		17.0	3.8	1	19.5	365.0	10.0	8.0	3.5	52.5	184.5

Table 8 (continued) Fish

Sample #	Location	Type	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	Zn
F1	P7	Long spine porgy	<1	<1	3.0	2.5	65.0	<1	3.2	3.0	3.5	32.5
F2	P7	Snapper	<1	<1	<1	3.5	60.0	<1	5.8	2.0	3.5	29.5
3	P7	Cynoscian arenarius	<1	1.5	33.0	3.0	55.0	<1	<1	4.0	3.5	42.5
4	J9	midshipman	<1	1.0	9.0	5.5	100.0	<1	3.3	3.0	3.0	55.5
5	S2	Cynoscian arenarius	<1	<1	<1	2.5	70.0	<1	15.5	4.0	2.0	83.0
6	S3	Snapper	<1	<1	<1	1.5	65.0	<1	10.5	2.6	1.5	25.5
7	S3	Cynoscian arenarius	<1	<1	<1	1.5	55.0	<1	12.8	2.5	2.0	48.0
8	Y1	Sciaenops ocellata (Belly)	<1	<1	<1	1.5	47.5	<1	<1	7.0	1.0	26.5
9	Y1	Sciaenops ocellata (Dorsal)	<1	<1	<1	2.0	42.5	<1	<1	7.8	1.0	24.3
10	X4	Pogonius cromis (Belly)	<1	<1	<1	2.8	60.0	<1	<1	13.0	2.0	32.0
11	X4	Pogonius cromis (Dorsal)	<1	<1	17.5	2.5	52.5	<1	<1	6.8	1.3	41.0
12	X4	Pogonius cromis (Belly)	<1	<1	61.8	3.3	100.0	<1	<1	9.5	2.8	44.3
13	X4	Pogonius cromis (Dorsal)	<1	<1	9.0	3.0	120.0	<1	<1	10.2	1.8	85.5
14	P1	Pogonius cromis (Belly)	<1	<1	5.5	2.5	65.0	<1	<1	8.8	2.3	38.0
15	P1	Pogonius cromis (Dorsal)	<1	<1	<1	2.3	67.5	<1	<1	9.3	1.8	48.3
16	P2	Raja texana	<1	<1	<1	1.3	30.0	<1	<1	6.0	1.5	18.8
17	P2	Raja texana	<1	<1	<1	1.8	40.0	<1	<1	6.8	5.0	25.8
18	X4	Micropogon undulatas	<1	<1	<1	3.5	117.5	<1	<1	7.0	6.0	34.0
19	X4	Arius felis	<1	<1	<1	2.8	62.5	<1	<1	5.0	5.5	67.5
20	Jacket G	Triggerfish	<1	<1	15.8	4.0	35.0	<1	<1	7.8	1.3	52.0
21	Jacket O	Triggerfish	<1	<1	6.8	0.5	45.0	<1	<1	7.3	1.5	40.5
22	Jacket O	Triggerfish	<1	<1	<1	2.3	32.5	<1	<1	7.5	1.8	40.3
23	Jacket O	Triggerfish	<1	<1	<1	2.8	35.0	<1	<1	8.0	1.8	36.2

Table 8 (continued)

Sample #	From Fish Sample		Ba	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	Zn
		Fish Livers											
L3	F 8-9	Scienops ocellata		1.2	<1	26.2	28.5	662.5	4.0	<1	6.0	3.0	102.2
L4	F10-11	Pogonius cromis		10.8	<1	13.8	60.0	505.0	6.0	<1	13.5	3.8	116.5
L5	F12-13	Pogonius cromis		11.2	<1	<1	57.2	900.0	4.2	<1	8.8	22.5	88.8
L6	F14-15	Pogonius cromis		15.2	<1	<1	154.0	520.0	5.5	<1	8.0	3.0	130.8
L7	F16	Raja texana		<1	<1	<1	112.5		7.8	<1	7.5		57.0
L8	F17	Raja texana		<1	<1	<1	25.0		1.5	<1	10.8		25.5
		Shrimp											
Sample #													
S1	T3	With vein		<1	6	<1	46.5	120.0	<1	2.0	5.5	47.5	123.0
S2	T3	Without vein			2.8	<1	23.5	55.0		<1	3.5	42.0	105.5
S3	K-9	With vein			<1	<1	23.5	60.0		2.4	4.5	30.5	109.5
S4	K-9	Without vein			1.5	<1	39.0	95.0		6.0	6.0	38.0	122.5
S5	S2	With vein			1.0	<1	41.0	90.0		6.0	5.5	20.0	103.0
S6	S2	Without vein			2.5	1.5	30.5	50.0		9.5	2.0	16.5	102.0
S7	Q8	With vein			1.0	<1	45.0	85.0		10.5	2.5	25.0	112.0
S8	Q8	Without vein			3.5	<1	34.0	60.0		22.5	4.0	36.0	99.0
S9	P7	With vein			1.5	<1	28.5	85.0		22.0	8.5	18.5	103.0
S10	P7	Without vein			<1	<1	23.0	70.0		11.5	5.0	15.5	101.5
		Plankton											
Sample #													
P1	Area X and Y			<1	12.3	77.5	86.8		88.3	39.0	348.8		234.3
P2	Area X and Y			<1	9.3	43.3	47.2		57.0	25.5	185.3		205.5
P3	Area P			<1	12.0	108.3	100.0		101.0	41.0	469.0		228.5
		Squid											
Sample #													
S1	U4			<1	1.5	<1	13.0	67.5	1.3	<1	4.8	9.8	67.3
S2	P7			<1	<1	<1	17.0	47.5	<1	<1	4.3	6.0	53.8

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TABLE 9

The average concentrations and range of concentrations for selected trace metals in organisms from the Buccaneer Field Study compared with similar data from BLM's South Texas Outer Continental Shelf Study. Data is presented only for those elements that were analyzed in both studies.

	Barnacles		Shrimp			
	NOAA		NOAA		BLM	
	Av.	Range	Av.	Range	Av.	Range
Cd	19.20	11.00- 25.00	.8	.5 - 1.5	.12	.05- .33
Cr	2.70	<.10- 64.25	<.1	0 - <.1	2.10	.40- 3.80
Cu	18.20	12.50- 27.25	25.8	23.0- 46.5	24.30	22.50-28.50
Mn	10.62	5.50- 18.50	1.75	.5 - 3	--	---
Pb	7.80	3.50- 11.50	4.6	2 - 8.5	.95	.60- 1.80
Zn	200.80	151.50-281.00	108.0	99 -123	47.90	20.50-57.50

	Fish				Fish Liver			
	NOAA		BLM		NOAA		BLM	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
Cd	<.10	0.00- <.10	.11	.05- .21	6.40	<.10- 15.25	3.70	.70- 6.1
Cr	5.90	<.10-61.75	1.30	1.00- 2.00	6.60	<.10- 26.25	2.20	2.00- 2.2
Cu	2.60	.50- 5.50	.66	.50- .90	72.80	25.00-154.00	14.70	9.00- 15.00
Mn	<.10	0.00- <.10	.18	.10- .30	4.80	1.50- 7.75	3.40	3.00- 4.7
Pb	<.10	0.00- <.10	1.30	.30- 2.90	9.10	6.00- 13.50	2.80	1.00- 7.6
Zn	41.60	24.25-85.50	10.20	.60-11.70	86.80	25.50-130.75	146.40	100.00-268.00

	Plankton				Squid			
	NOAA		BLM		NOAA		BLM	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
Cd	<.10	.00- <.10	4.72	.86- 5.25	<.10	.00- <.10	1.03	.91- 1.1
Cr	88.30	55.25-120.25	18.00	1.90-82.00	2.75	2.50- 3.00	4.70	3.00- 6.10
Cu	78.00	47.25-100.00	14.20	2.70-61.00	15.00	13.00- 17.00	65.70	61.00- 69.00
Mn	82.10	57.00-101.00	---	---	2.00	1.50- 2.50	---	-----
Pb	334.30	185.25-469.00	42.40	3.10-474.00	4.50	4.25- 4.75	2.00	1.30- 2.7
Zn	222.75	205.50-234.25	134.10	26.50-560.00	60.50	53.75- 67.25	144.00	50.00-290.00

Table 10

Pipeline Size Calculations

Anomaly Location Seismic Line Station		Magnitude and Sign (Measured)	Interpretation (i.e. pipeline & diameters(s))	Expected Anomaly (calculated)*	Agree	Remarks
16	20-21	+ 88γ	6" and 4" + 1"	61.5γ	too large	Due to remanent magnetism - change with different lengths of pipe
	24-28	-	Platform			
15	21-22	+~40γ	6" and 4" + 1"	61.5γ	too small	
	25-26					
	26-27	+ 12γ each	2-4" + 1"	27γ each	too small	"
14	19-20	29γ	4" + 1"	27.06γ	too small	
	21	25γ	4" + 1"	"	"	
	22-23	30γ	6"	34.03γ	"	
	23-24	22γ	4" + 1"	27.06	"	
	24-25	27γ	4" + 1"	27.06	"	
	26	21γ	4"	22.4	"	
13	17	14γ	3"	16.6	"	
	18½	- 34γ	6"	34.03	"	Remanent Mag.
	19½	180-190γ	20" - 10"		"	
	21	25γ	10"		"	
	22	14γ	2"	10.8γ	"	
12	14	30γ	6"	34.03	"	
	15-16	50γ	10"	57	"	
	16-17	110γ	20"	117	"	
	17½	-~60γ	10"	+57	"	
	25½	32γ	2"	10.8	Too large	Effect of nearby pipelines

TABLE 11

Summary statistics of the sedimentary size parameters (in Wt. %)

	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION*
-1.00	28.70	0.0	3.63	5.04	1.39
-0.75	19.94	0.0	0.90	2.79	3.09
-0.50	15.28	0.0	0.79	2.54	3.22
-0.25	15.50	0.0	0.76	2.56	3.36
0.00	12.64	0.0	0.53	1.94	3.63
0.25	10.17	0.0	0.52	1.58	3.02
0.50	7.06	0.0	0.43	1.25	2.90
0.75	5.44	0.01	0.39	0.95	2.42
1.00	2.11	0.01	0.24	0.47	2.00
1.25	1.29	0.0	0.16	0.27	1.73
1.50	2.00	0.0	0.22	0.37	1.70
1.75	2.74	0.0	0.39	0.55	1.43
2.00	2.99	0.0	0.30	0.50	1.64
2.25	4.97	0.0	0.49	0.72	1.49
2.50	6.86	0.0	0.70	0.91	1.31
2.75	19.98	0.0	4.45	2.91	0.65
3.00	26.13	0.0	7.13	4.34	0.61
3.25	23.83	0.0	12.46	6.17	0.50
3.50	26.39	0.0	15.96	6.94	0.43
3.75	24.03	0.0	10.95	5.36	0.49
4.00	13.67	0.0	3.54	2.15	0.61
%SILT	61.35	0.93	18.48	11.76	0.64
%CLAY	67.62	0.0	16.35	11.18	0.68

* the coefficient of variation is the standard deviation devided by the mean multiplied by 100 (C.V. = $\sigma/\mu \times 100$). The C.V. values reported in this report were not multiplied by 100; therefore, a C.V. equal to 1.39 in the table above is really 139% variation.

TABLE 12

Mean sedimentary size parameters for the cluster groups defined on the Q-mode dindrogram (Figure 2.3-22)

Sedimentary Size Parameters	Group 1 MEAN	Group 2A MEAN	Group2B MEAN	Group 2C MEAN	Group 3 MEAN	Texturally Anomalous Sample
-1.0	2.20	1.27	0.20	3.53	22.47	
-0.75	0.34	0.29	0.03	0.37	14.82	
-0.50	0.22	0.18	0.04	0.24	13.64	
-0.25	0.19	0.19	0.02	0.26	13.84	
0.00	0.12	0.06	0.02	0.11	10.32	
0.25	0.11	0.12	0.02	0.11	7.02	
0.50	0.10	0.10	0.02	0.09	5.19	
0.75	0.16	0.11	0.04	0.09	4.59	
1.00	0.09	0.12	0.02	0.05	1.75	
1.25	0.07	0.11	0.02	0.06	0.62	
1.50	0.10	0.18	0.05	0.07	0.37	
1.75	0.18	0.28	1.79	0.14	0.19	
2.00	0.18	0.24	0.39	0.13	0.08	
2.25	0.34	0.35	0.18	0.28	0.02	
2.50	0.62	0.47	0.30	0.44	0.02	
2.75	5.48	3.66	3.90	3.67	0.05	
3.00	10.98	3.90	7.43	6.75	0.04	
3.25	13.81	9.22	17.16	11.23	0.06	
3.50	22.25	17.40	17.90	15.19	0.05	
3.75	10.13	19.37	10.22	11.29	0.09	
4.00	2.61	6.25	3.59	3.51	0.01	
%SILT	13.56	14.89	21.70	25.71	2.19	
%CLAY	10.90	21.35	16.16	15.28	0.0	
Number of samples in each group	23	13	2	21	3	23
Map symbol used to identify group on Fig. 2.3-23	★	□	✪	●	○	▲

TABLE 13

Summary statistics of sedimentary size parameters for each of the five cluster groups defined on the Q-mode dindrogram (Figure 2.3-22) and plotted on Figure 2.3-23 and 2.3-24

A) Group 1

	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION
-1.00	6.86	0.10	2.20	1.89	0.86
-0.75	1.11	0.0	0.34	0.27	0.80
-0.50	0.59	0.02	0.22	0.13	0.60
-0.25	0.32	0.02	0.19	0.08	0.45
0.00	0.27	0.01	0.12	0.07	0.63
0.25	0.36	0.02	0.11	0.07	0.59
0.50	0.24	0.02	0.10	0.05	0.47
0.75	1.10	0.04	0.16	0.21	1.36
1.00	0.59	0.02	0.09	0.11	1.17
1.25	0.22	0.02	0.07	0.04	0.64
1.50	0.21	0.04	0.10	0.04	0.41
1.75	0.31	0.09	0.18	0.05	0.26
2.00	0.36	0.07	0.18	0.06	0.37
2.25	0.66	0.15	0.34	0.14	0.42
2.50	1.61	0.35	0.62	0.25	0.40
2.75	7.76	2.39	5.48	1.48	0.27
3.00	16.65	4.10	10.96	2.97	0.27
3.25	23.83	13.60	18.81	2.63	0.14
3.50	26.25	15.46	22.25	2.23	0.10
3.75	19.70	7.16	10.13	2.93	0.29
4.00	4.18	1.58	2.61	0.79	0.30
%SILT	23.91	3.63	13.58	5.53	0.41
%CLAY	20.03	0.0	10.90	5.29	0.49

B) Group 2A

	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION
-1.00	3.36	0.36	1.27	0.81	0.64
-0.75	0.64	0.06	0.29	0.19	0.67
-0.50	0.36	0.09	0.18	0.09	0.52
-0.25	0.35	0.08	0.19	0.09	0.45
0.00	0.22	0.0	0.06	0.06	1.01
0.25	0.22	0.05	0.12	0.06	0.48
0.50	0.24	0.02	0.10	0.06	0.61
0.75	0.34	0.03	0.11	0.08	0.77
1.00	0.39	0.04	0.12	0.10	0.85
1.25	0.30	0.03	0.11	0.08	0.73
1.50	0.38	0.06	0.18	0.13	0.70
1.75	0.51	0.13	0.28	0.13	0.48
2.00	0.47	0.08	0.24	0.13	0.54
2.25	0.54	0.13	0.35	0.13	0.38
2.50	0.78	0.29	0.47	0.14	0.29
2.75	5.59	2.43	3.66	0.78	0.21
3.00	5.72	2.37	3.90	1.10	0.28
3.25	15.05	5.81	9.22	2.89	0.31
3.50	26.39	10.50	17.40	5.61	0.32
3.75	24.03	15.99	19.37	2.25	0.12
4.00	7.81	3.97	6.25	1.34	0.21
%SILT	27.62	6.73	14.39	5.89	0.40
%CLAY	32.02	13.05	21.35	4.93	0.23

C) Group 2B

	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION
-1.0	0.21	0.20	0.20	0.01	0.03
-0.75	0.04	0.03	0.03	0.01	0.20
-0.50	0.07	0.01	0.04	0.04	1.06
-0.25	0.03	0.02	0.02	0.01	0.28
0.00	0.02	0.01	0.02	0.01	0.47
0.25	0.02	0.01	0.02	0.01	0.47
0.50	0.02	0.02	0.02	0.0	0.0
0.75	0.07	0.02	0.04	0.04	0.79
1.00	0.03	0.02	0.02	0.01	0.28
1.25	0.03	0.02	0.02	0.01	0.28
1.50	0.06	0.04	0.05	0.01	0.28
1.75	2.15	1.43	1.79	0.51	0.28
2.00	0.12	0.06	0.09	0.04	0.47
2.25	0.22	0.14	0.18	0.06	0.31
2.50	0.36	0.24	0.30	0.08	0.28
2.75	4.33	3.47	3.90	0.61	0.16
3.00	8.30	6.57	7.43	1.22	0.16
3.25	18.81	15.56	17.18	2.30	0.13
3.50	20.52	15.28	17.90	3.71	0.21
3.75	10.67	9.78	10.22	0.63	0.06
4.00	3.67	3.51	3.59	0.11	0.03
%SILT	22.19	21.21	21.70	0.69	0.03
%CLAY	21.68	10.45	16.16	8.08	0.50

D) Group 2C

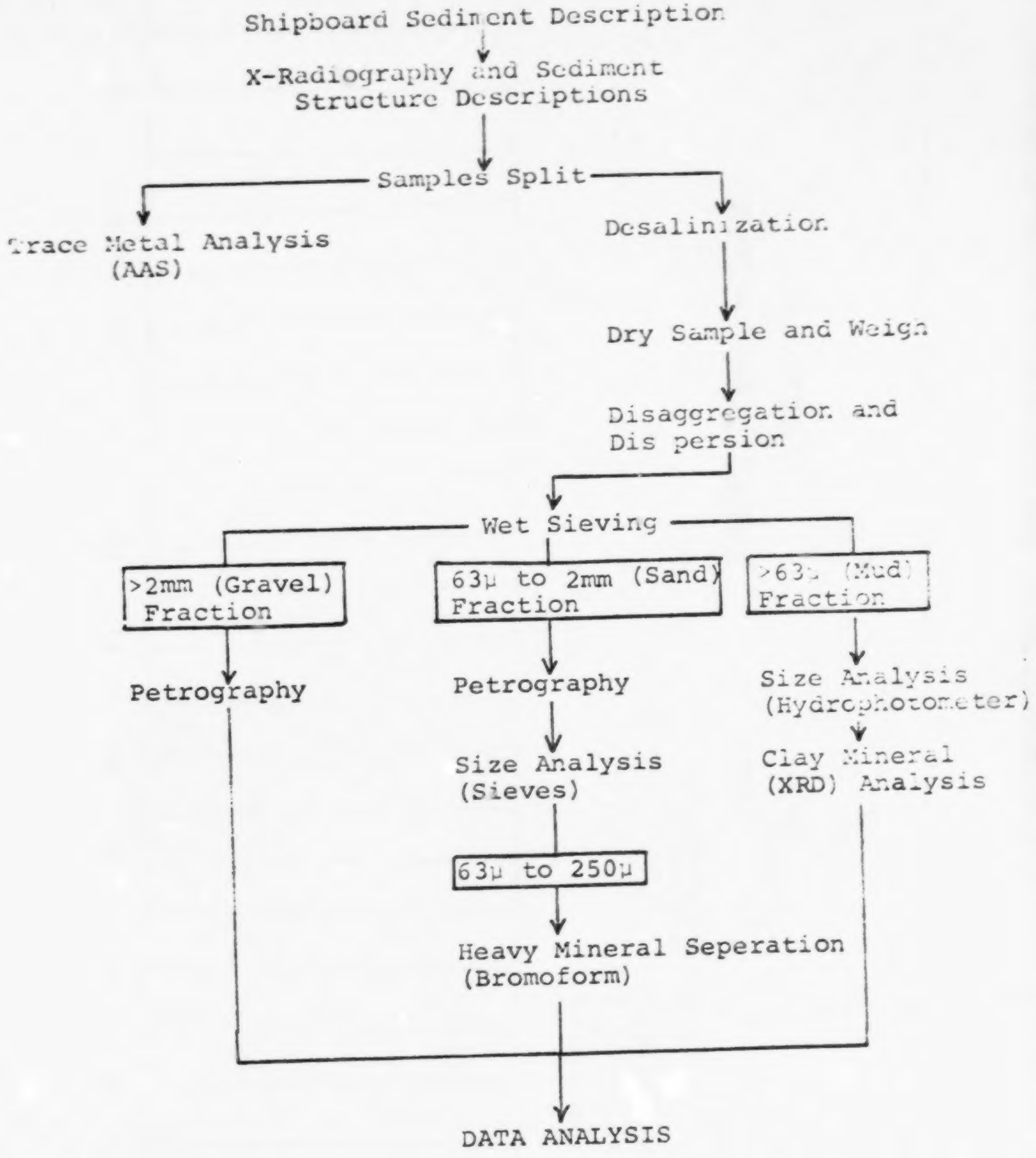
	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION
-1.0	11.77	0.20	3.53	2.93	0.83
-0.75	1.03	0.01	0.37	0.26	0.69
-0.50	0.61	0.01	0.24	0.15	0.63
-0.25	1.93	0.02	0.28	0.40	1.43
0.00	0.51	0.01	0.11	0.11	1.00
0.25	0.31	0.01	0.11	0.08	0.79
0.50	0.24	0.02	0.09	0.07	0.77
0.75	0.29	0.01	0.09	0.07	0.79
1.00	0.18	0.01	0.05	0.04	0.83
1.25	0.31	0.01	0.06	0.07	1.10
1.50	0.15	0.02	0.07	0.04	0.55
1.75	0.24	0.08	0.14	0.05	0.33
2.00	0.25	0.04	0.13	0.05	0.42
2.25	0.67	0.13	0.28	0.13	0.45
2.50	1.70	0.24	0.44	0.30	0.68
2.75	5.78	2.19	3.67	1.03	0.28
3.00	8.63	4.42	6.75	1.10	0.16
3.25	14.32	7.46	11.23	1.79	0.16
3.50	19.62	11.35	15.19	2.66	0.18
3.75	14.29	6.51	11.29	1.71	0.15
4.00	5.89	1.54	3.51	1.00	0.29
%SILT	37.75	15.64	25.71	7.17	0.28
%CLAY	32.26	4.12	16.28	6.83	0.42

E) Group 3

	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION
-1.0	28.70	14.41	22.47	7.32	0.33
-0.75	19.94	11.55	14.82	4.49	0.30
-0.50	15.28	11.64	13.64	1.85	0.14
-0.25	15.50	12.30	13.84	1.60	0.12
0.00	12.64	8.52	10.32	2.11	0.20
0.25	10.17	4.54	7.02	2.88	0.41
0.50	6.47	3.48	5.19	1.54	0.30
0.75	5.44	3.40	4.59	1.06	0.23
1.00	2.11	1.17	1.75	0.51	0.29
1.25	0.84	0.38	0.62	0.23	0.37
1.50	0.68	0.18	0.37	0.27	0.73
1.75	0.36	0.08	0.19	0.15	0.79
2.00	0.11	0.03	0.08	0.04	0.54
2.25	0.07	0.0	0.02	0.04	1.73
2.50	0.05	0.0	0.02	0.03	1.73
2.75	0.14	0.0	0.05	0.08	1.73
3.00	0.13	0.0	0.04	0.08	1.73
3.25	0.19	0.0	0.06	0.11	1.73
3.50	0.15	0.0	0.05	0.09	1.73
3.75	0.26	0.0	0.09	0.15	1.73
4.00	0.03	0.0	0.01	0.02	1.73
%SILT	4.57	0.93	2.19	2.06	0.94
%CLAY	0.0	0.0	0.0	0.0	0.0

Figure 1

FORMAT FOR SEDIMENT ANALYSIS


Shipboard Sediment Description
X-Radiography and Sediment Structure Descriptions
Samples Split
Trace Metal Analysis (AAS)
Desalinization
Dry Sample and Weigh
Disaggregation and Dis persion
Wet Sieving
>2mm (Gravel) Fraction
63μ to 2mm (Sand) Fraction
>63μ (Mud) Fraction
Petrography
Petrography
Size Analysis (Hydrophotometer)
Size Analysis (Sieves)
Clay Mineral (XRD) Analysis
63μ to 250μ
Heavy Mineral Seperation (Bromoform)
DATA ANALYSIS

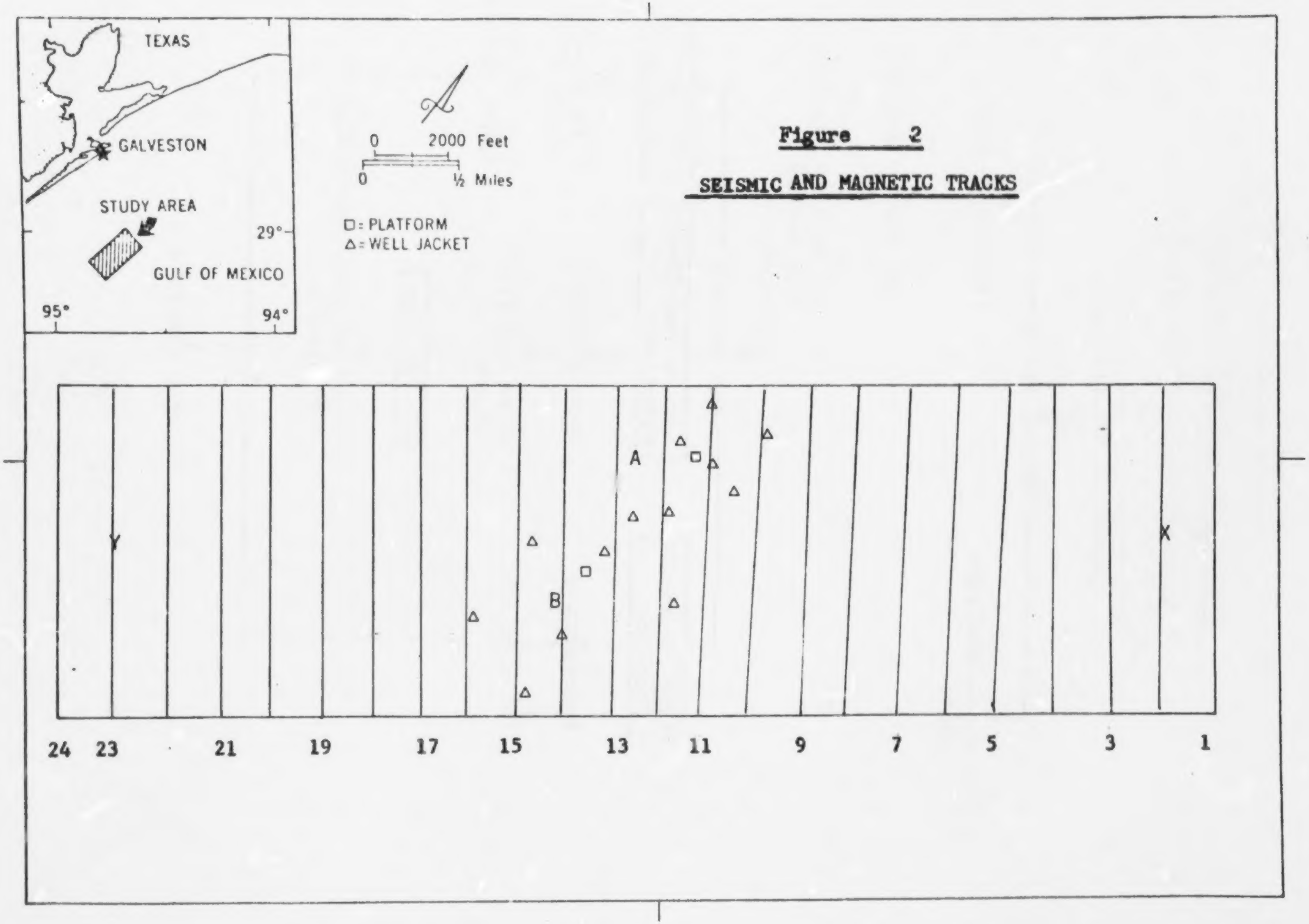
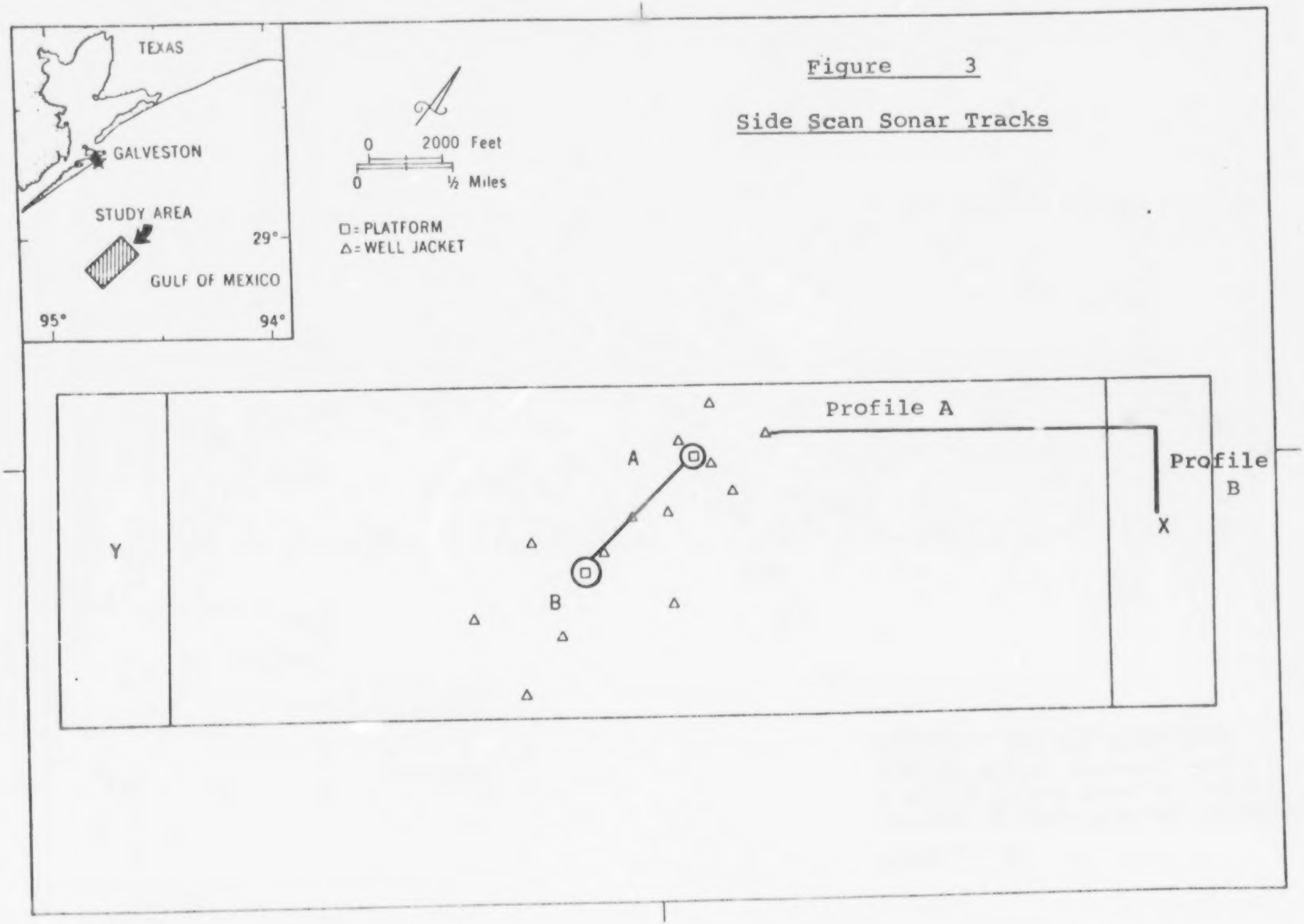

TEXAS
GALVESTON
STUDY AREA
29°
GULF OF MEXICO
95°
94°
0
2000 Feet
0
½ Miles
□ = PLATFORM
△ = WELL JACKET
A
B
X
Y
24
23
21
19
17
15
13
11
9
7
5
3
1

Figure 2

SEISMIC AND MAGNETIC TRACKS



TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0
2000 Feet
0
½ Miles
□= PLATFORM
△= WELL JACKET
Profile A
Profile B
A
B
X
Y

Figure 3

Side Scan Sonar Tracks

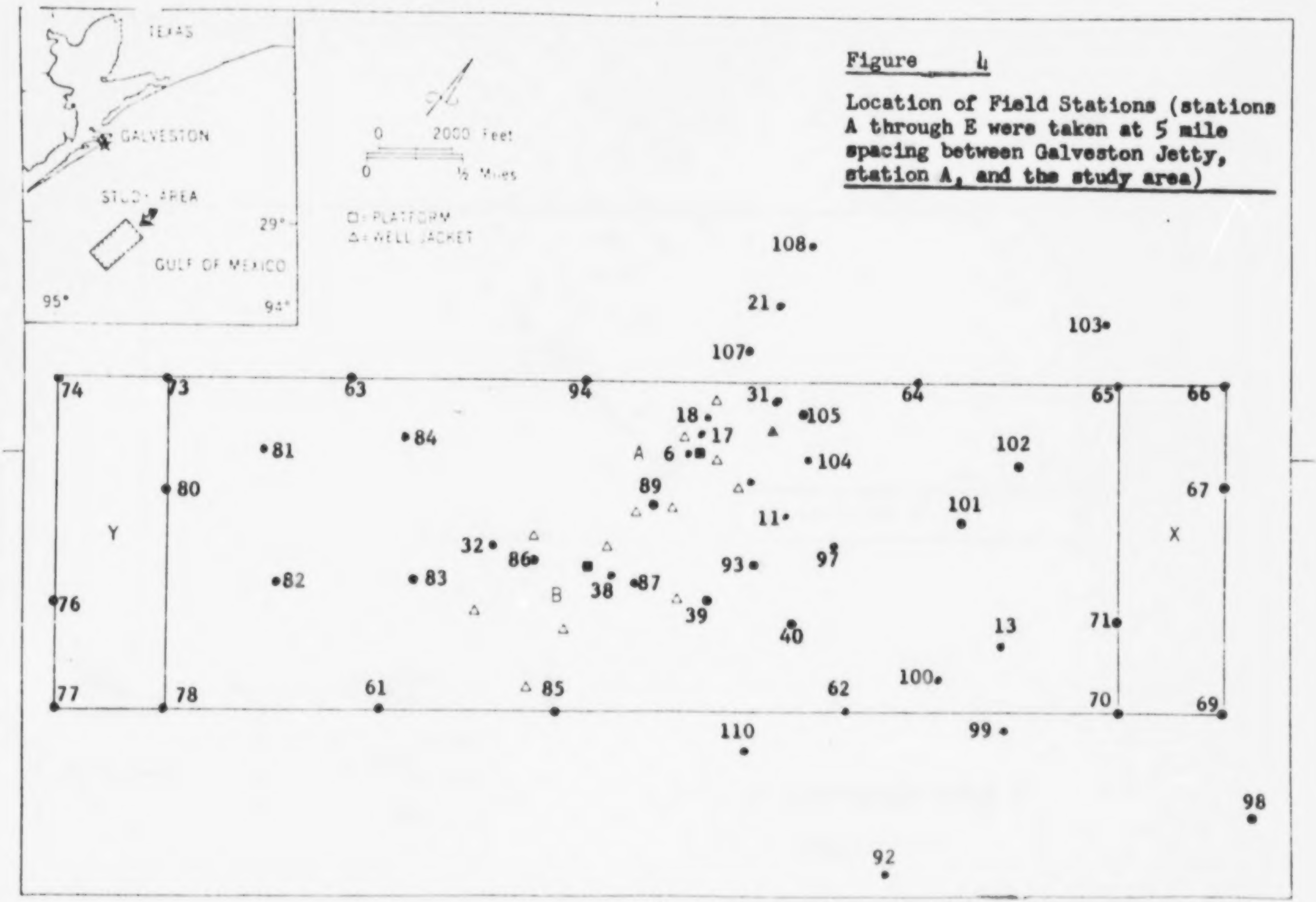
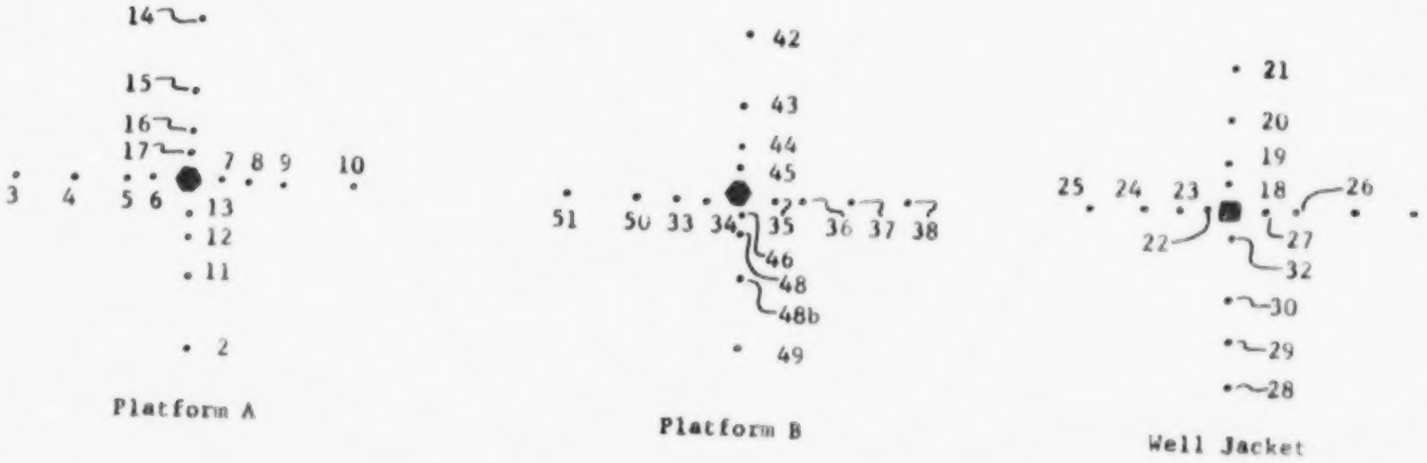

TEXAS
GALVESTON
STUDY AREA
29°
GULF OF MEXICO
95°
94°
0 2000 Feet
0 ½ Miles
□=PLATFORM
△=WELL JACKET
108
21
103
107
74
73
63
94
31
64
65
66
18
105
17
84
81
A
6
104
102
80
89
67
101
Y
11
X
32
86
97
93
82
83
38
87
B
76
39
40
71
13
100
77
78
61
85
62
70
69
110
99
98
92

Figure 4

Location of Field Stations (stations A through E were taken at 5 mile spacing between Galveston Jetty, station A, and the study area)

Figure 5

Location of Stations taken within 375 feet of Platforms A and B and Well Jacket


14
15
16
17
7 8 9
10
3
4
5 6
13
12
11
2
Platform A
42
43
44
45
51
50 33 34
35
36 37 38
46
48
48b
49
Platform B
21
20
19
25 24 23
18
26
22
27
32
30
29
28
Well Jacket

Station Spacings 25, 75, 175 and 375 feet
Station 28 - 675 feet from Well Jacket

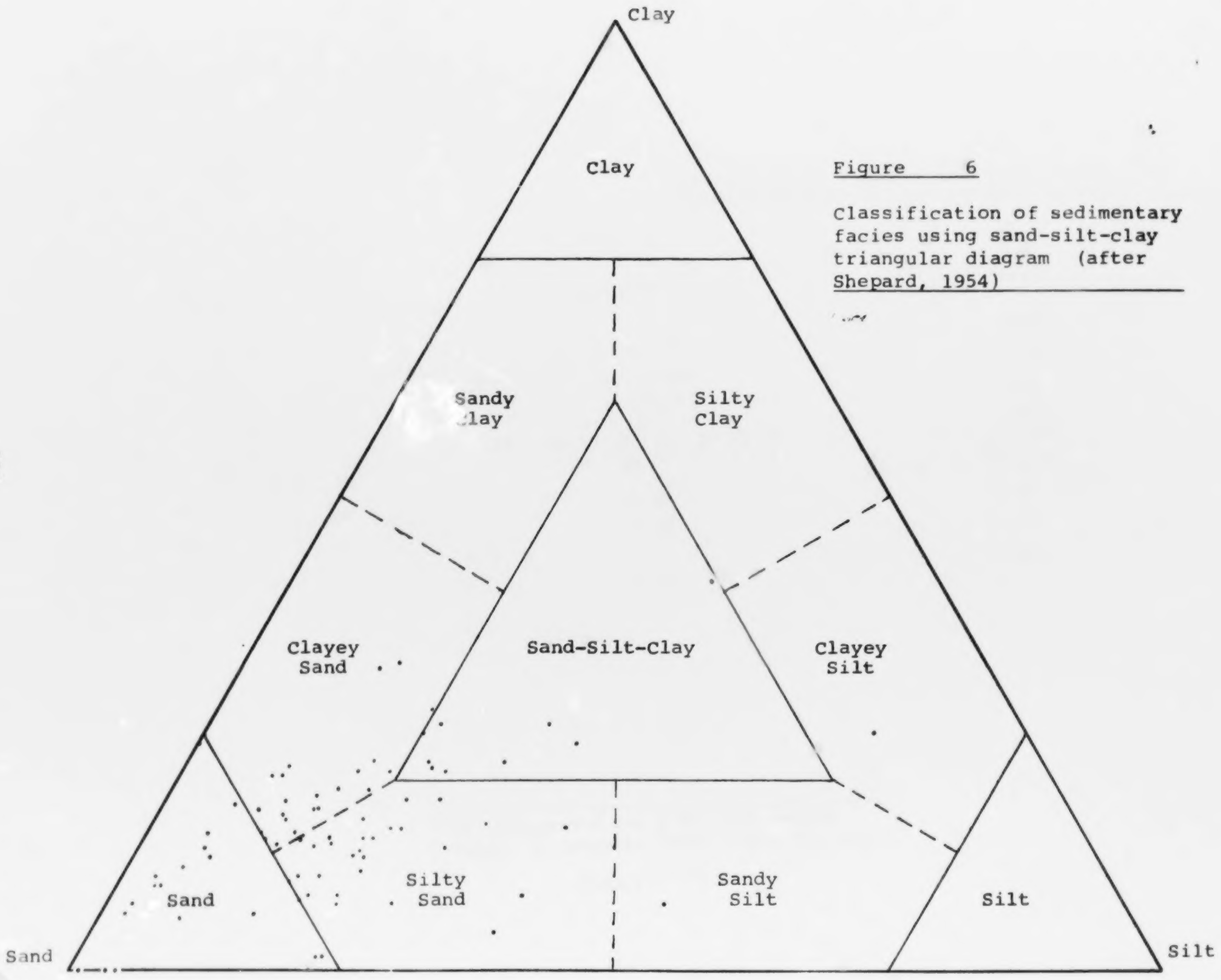


Figure 6

Classification of sedimentary facies using sand-silt-clay triangular diagram (after Shepard, 1954)

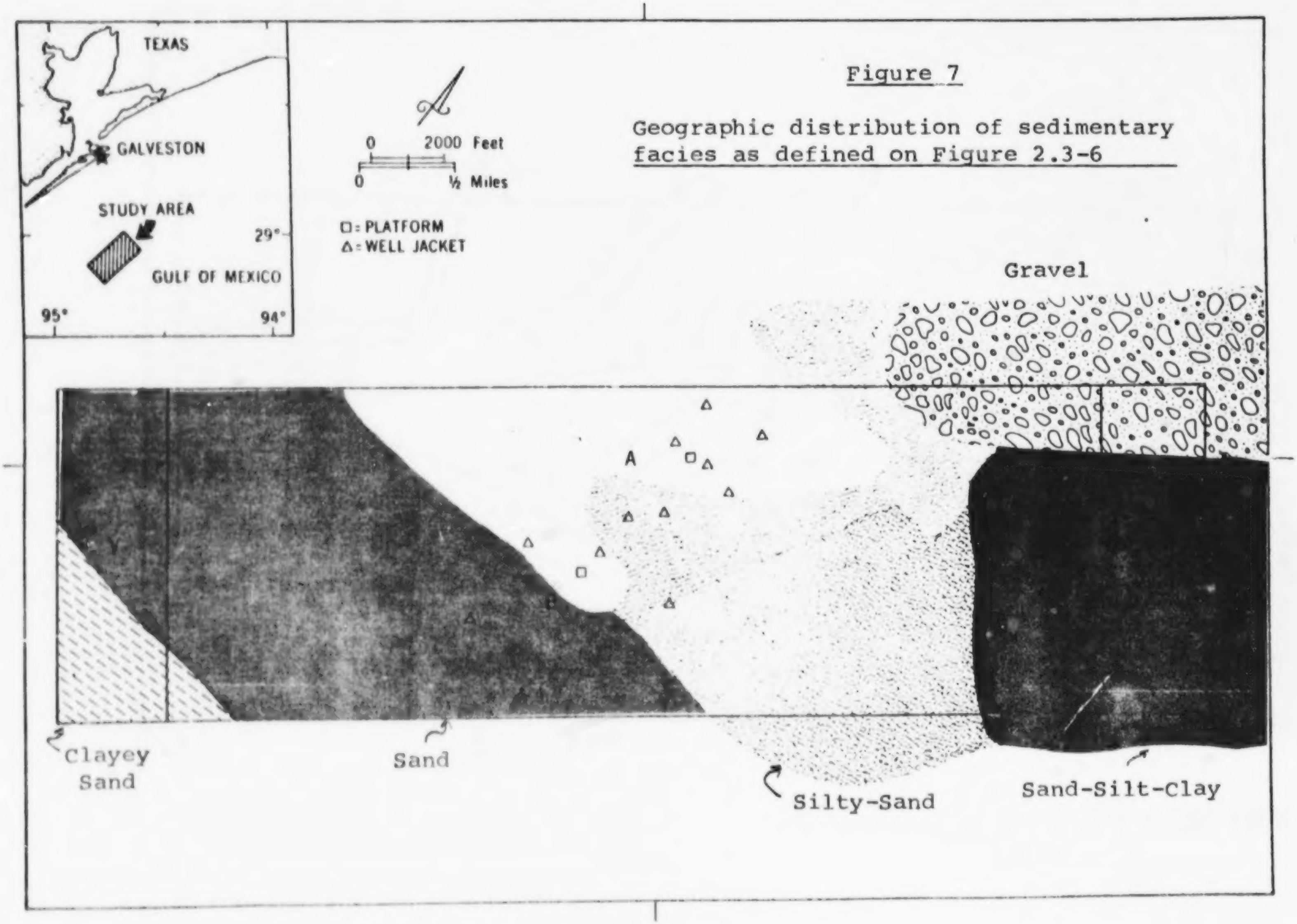

TEXAS
GALVESTON
STUDY AREA
29°
GULF OF MEXICO
95°
94°
0 2000 Feet
0 ½ Miles
□: PLATFORM
Δ: WELL JACKET
Gravel
A
Clayey Sand
Sand
Silty-Sand
Sand-Silt-Clay

Figure 7

Geographic distribution of sedimentary facies as defined on Figure 2.3-6

Figure 8

CONTOUR MAP OF SAND/MUD RATIOS OF THE FIELD SAMPLES

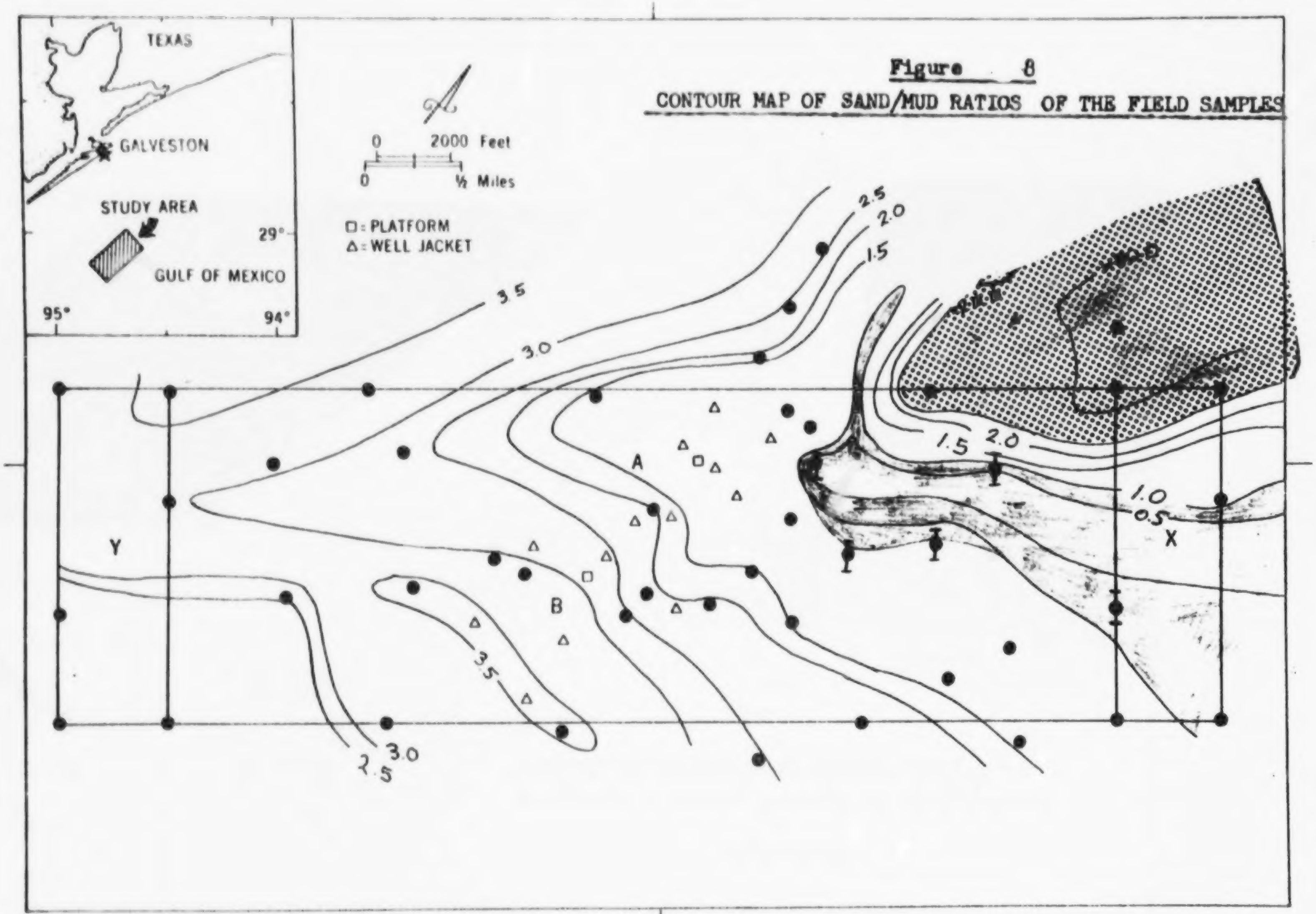
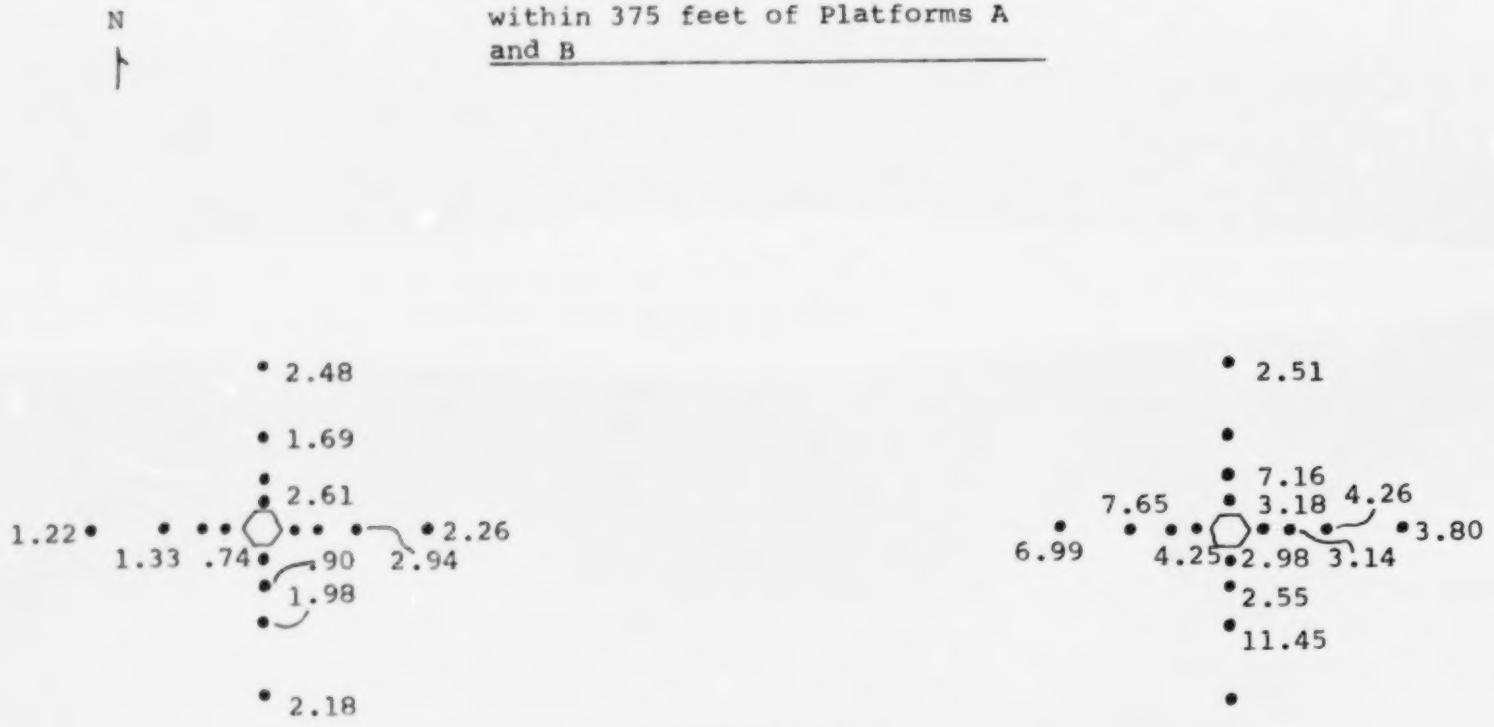

TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0
2000 Feet
0
½ Miles
□ = PLATFORM
△ = WELL JACKET
3.5
3.0
2.5
2.0
1.5
1.0
0.5
A
B
X
Y
3.5
3.0
2.5

Figure 9

Sand/Mud ratios of samples taken within 375 feet of Platforms A and B


N
2.48
1.69
2.61
1.22
1.33
.74
.90
1.98
2.94
2.26
2.18
2.51
7.16
7.65
3.18
4.26
6.99
4.25
2.98
3.14
3.80
2.55
11.45

Station Spacing
25'
75'
175'
375'

Platform A

Average S/M for area is
1.0 to 1.5 from Figure
2.3-6

Platform B

Average S/M for area is
2.5 to 3.5 from Figure
2.3-6

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Figure 10

Side Scan Sonar Profile

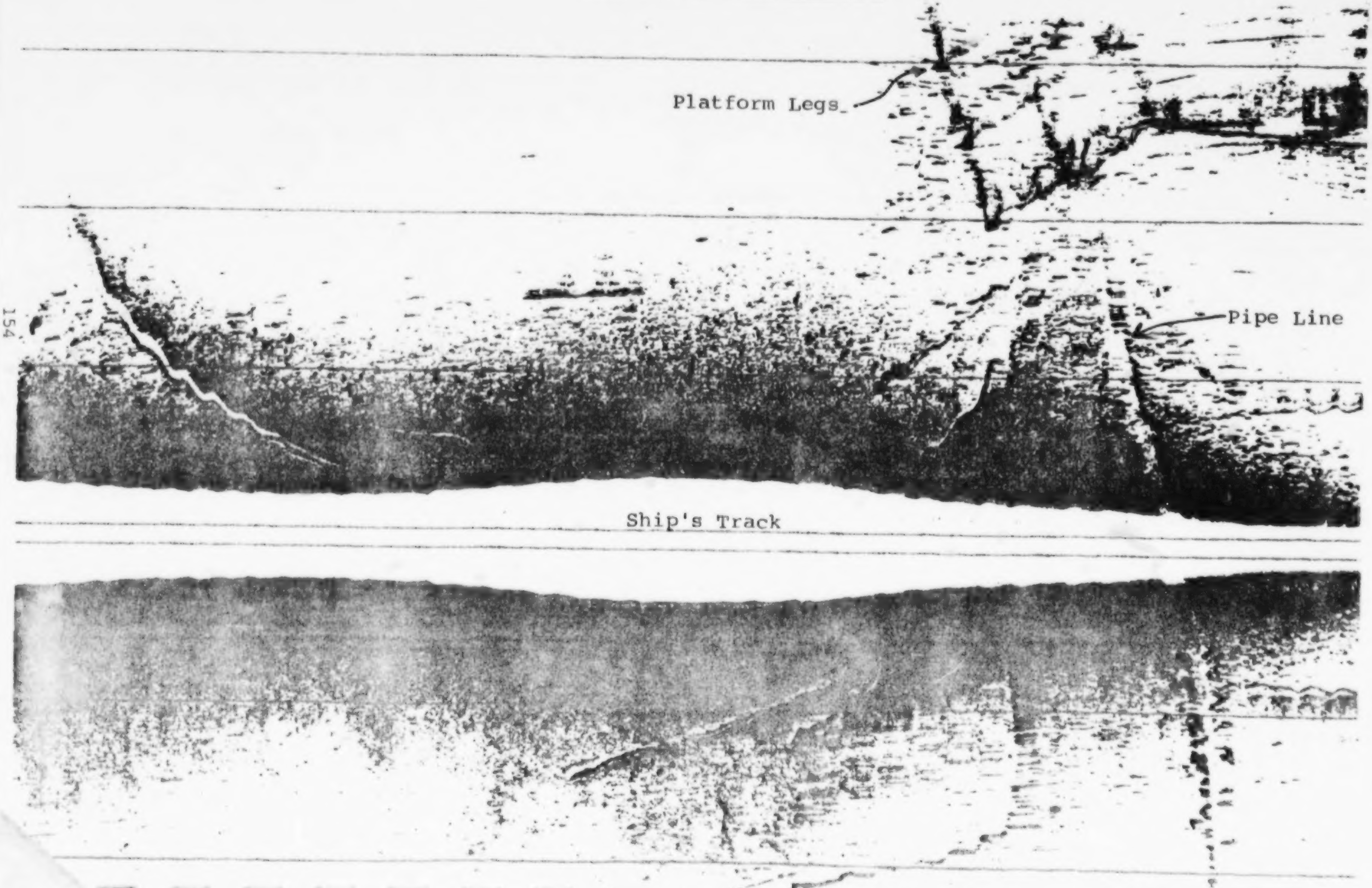
Platform Legs
Pipe Line
Ship's Track

Figure 11 X-ray Diffraction Patterns of Clay Minerals Showing the Shape of the Expendable Clays (001) Reflection

Shown below are the x-ray diffraction patterns (for 2θ to 2θ) of sediment samples #43 and #37. The (001) maximum reflection of the expendable clays is very sharp in sample #43 whereas it is quite broad in sample #37. See text for discussion. The diffraction peaks are labeled as follows: Q-quartz, F-feldspar, K-kaolinite, I-illite; and E-expandable clays.

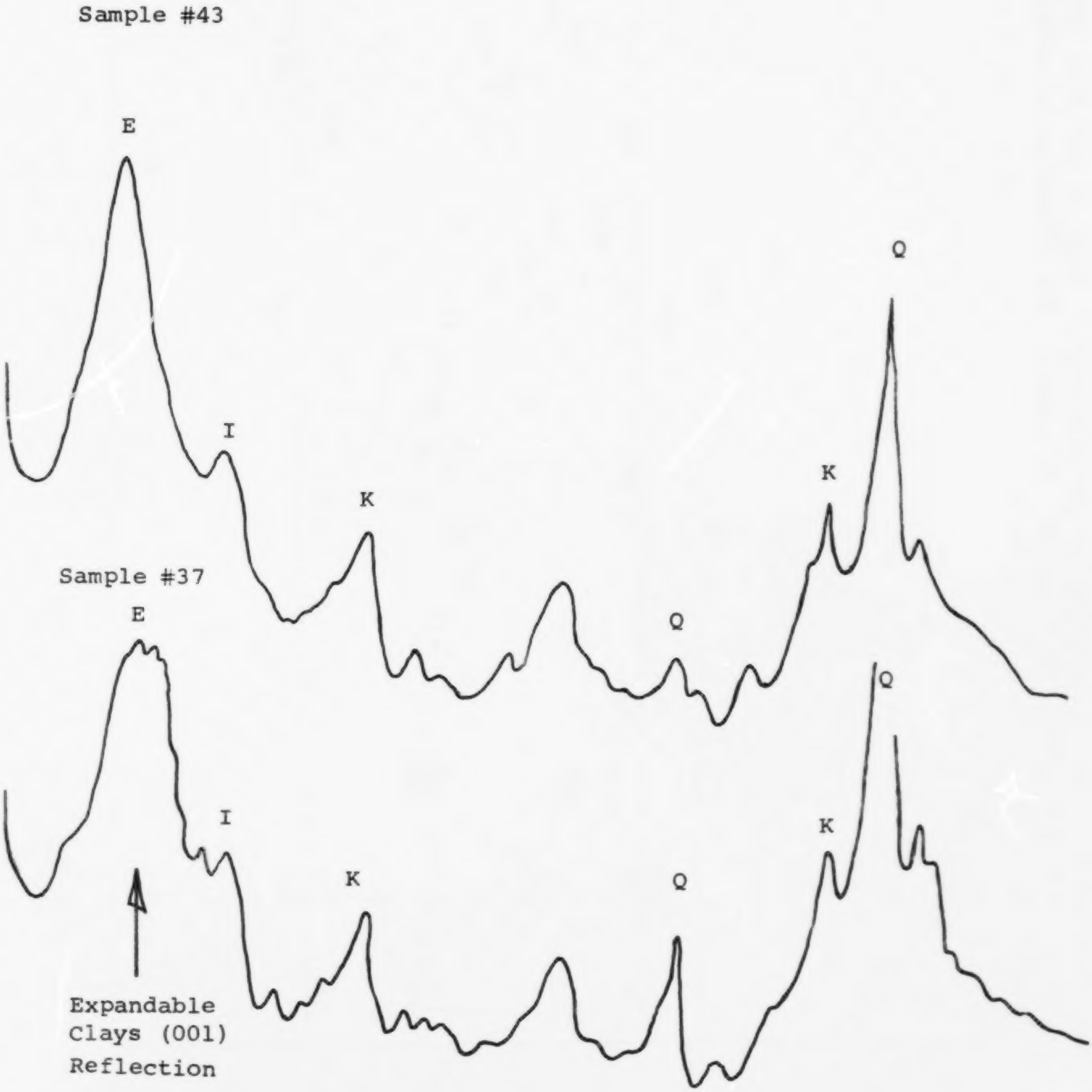

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Figure 12
Sharpness of the (001) reflection of the expandable clays in sediment samples taken from field stations. (s)-very sharp; (s-)- sharp; (B) broad. See Figure 11 for samples x-ray diffraction patterns.

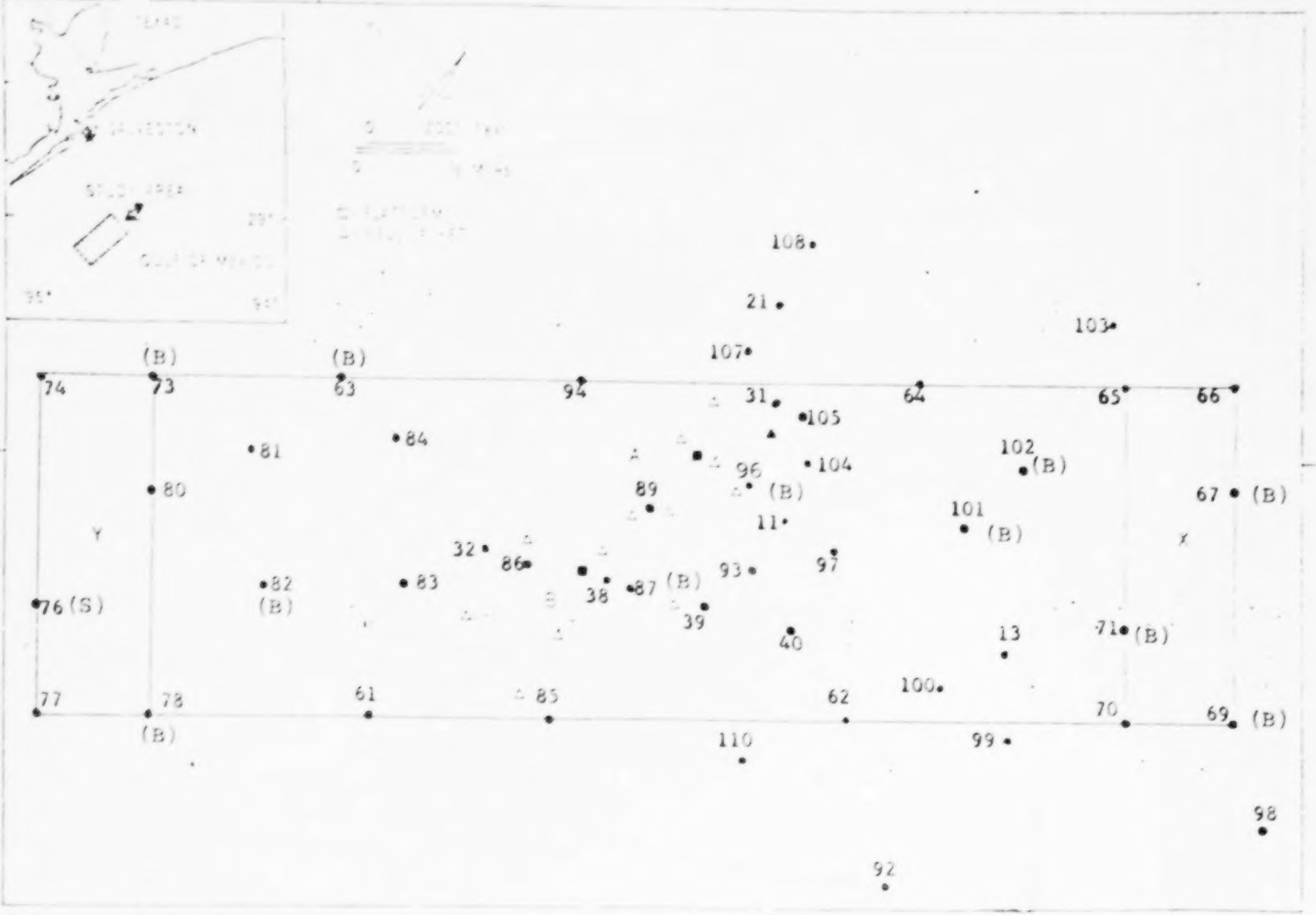
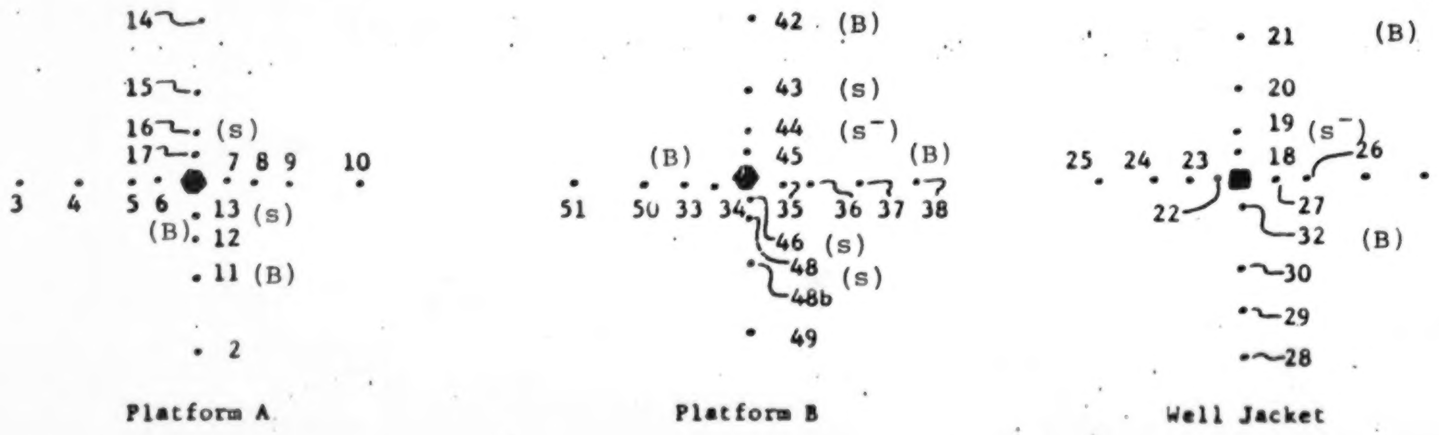

TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
108
21
103
107
(B)
74
73
(B)
63
94
31
105
64
65
66
81
84
80
89
96
(B)
104
102
(B)
67
(B)
101
(B)
11
Y
32
86
83
82
(B)
76 (S)
38
87
(B)
93
97
39
40
13
71
(B)
77
78
(B)
61
85
62
100
70
69
(B)
110
99
98
92

Figure 13

Sharpness of the (001) reflection of the expandable clays in sediment samples taken within 375 feet of platforms A and B and well jacket.
(s) - very sharp (s⁻)-sharp (B) broad
See Figure 11 for sample x-ray diffraction patterns.


14
15
16 (s)
17
7 8 9
10
3
4
5 6
13 (s)
(B) 12
11 (B)
2
Platform A
42 (B)
43 (s)
44 (s⁻)
45
(B)
(B)
51
50 33 34
35
36 37 38
46 (s)
48 (s)
48b
49
Platform B
21 (B)
20
19 (s⁻)
18
26
25 24 23
22
27
32 (B)
30
29
28
Well Jacket

Station Spacings 25, 75, 175 and 375 feet
Station 28 - 675 feet from Well Jacket

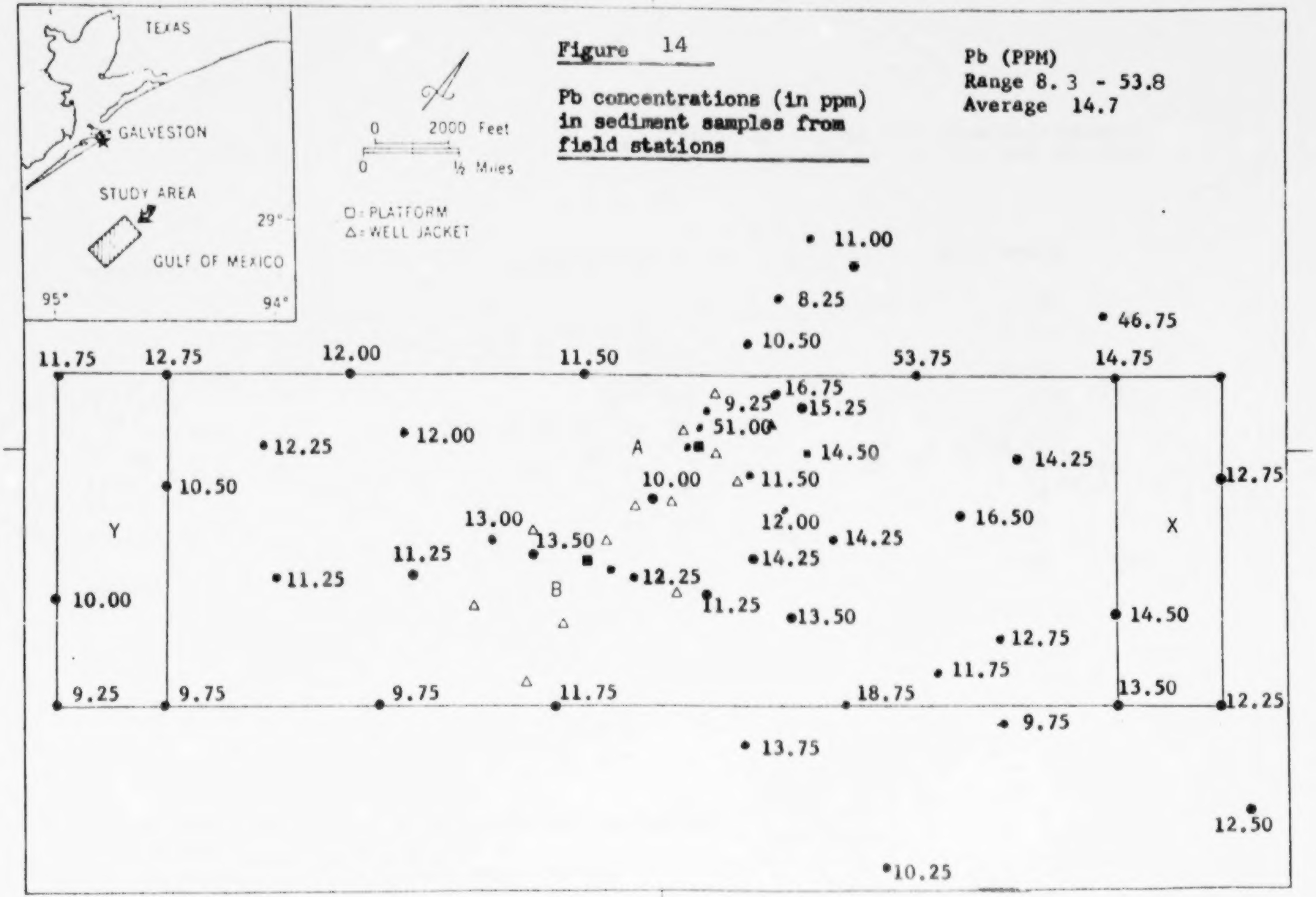

TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0 2000 Feet
0 ½ Miles
□ = PLATFORM
△ = WELL JACKET
11.00
8.25
10.50
46.75
11.75
12.75
12.00
11.50
53.75
14.75
9.25
16.75
15.25
51.00
A
12.25
12.00
14.50
14.25
10.50
10.00
11.50
12.75
Y
13.00
12.00
16.50
X
13.50
14.25
11.25
14.25
11.25
10.00
12.25
B
11.25
13.50
14.50
12.75
11.75
9.25
9.75
9.75
11.75
18.75
13.50
12.25
9.75
13.75
12.50
10.25

Figure 14

Pb concentrations (in ppm) in sediment samples from field stations

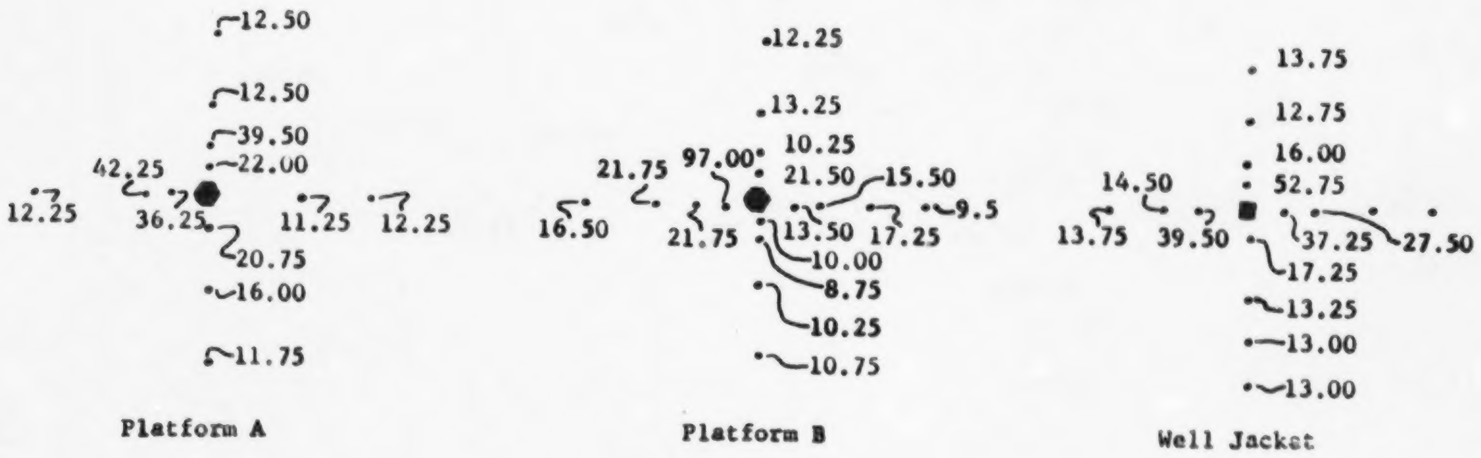
Pb (PPM)
Range 8. 3 - 53.8
Average 14.7

BLM
Range 2.2 - 16.5 PPM
Average 8.94 PPM

Pb (PPM)
Field Average 14.7

Figure 15

Pb concentrations (in ppm) in sediment samples from stations within 375 feet of platforms A and B and well jacket


12.50
12.50
39.50
22.00
42.25
12.25
36.25
11.25
12.25
20.75
16.00
11.75
Platform A
12.25
13.25
10.25
97.00
21.75
21.50
15.50
16.50
9.5
21.75
13.50
17.25
10.00
8.75
10.25
10.75
Platform B
13.75
12.75
16.00
52.75
14.50
13.75
39.50
37.25
27.50
17.25
13.25
13.00
13.00
Well Jacket

BLM
Range 2.2 - 16.5 PPM
Average 8.9 PPM

Figure 16

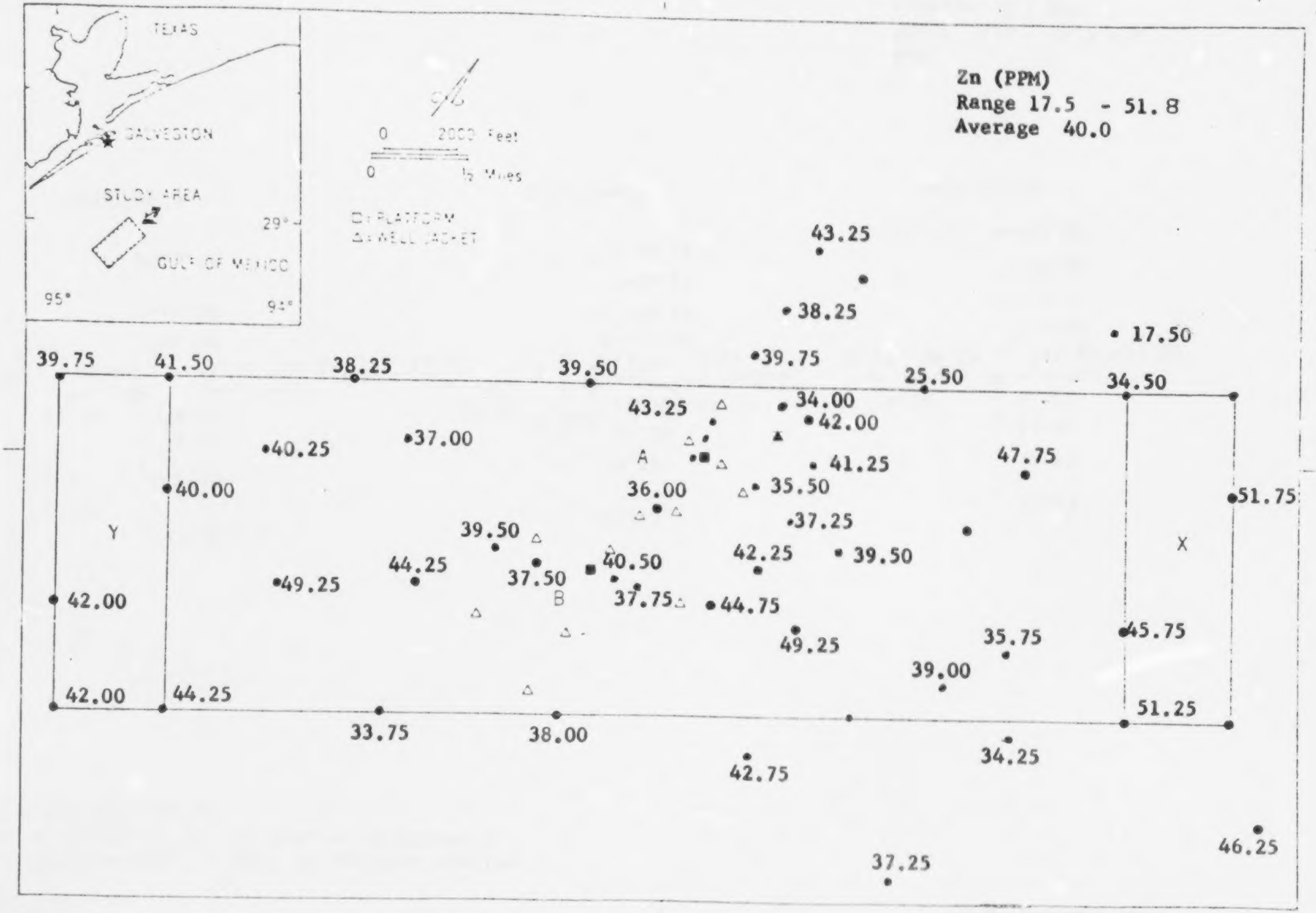

Zn (PPM)
Range 17.5 - 51.8
Average 40.0
TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0 2000 Feet
0 ½ Miles
□ PLATFORM
△ WELL JACKET
A
B
X
Y
39.75
41.50
38.25
39.50
25.50
34.50
51.75
43.25
38.25
39.75
17.50
43.25
34.00
42.00
41.25
35.50
37.25
39.50
47.75
40.25
37.00
40.00
36.00
39.50
44.25
37.50
40.50
42.25
49.25
42.00
37.75
44.75
49.25
35.75
45.75
39.00
42.00
44.25
33.75
38.00
51.25
42.75
34.25
46.25
37.25

Figure 17

Zn (PPM)
Field Average 40.0

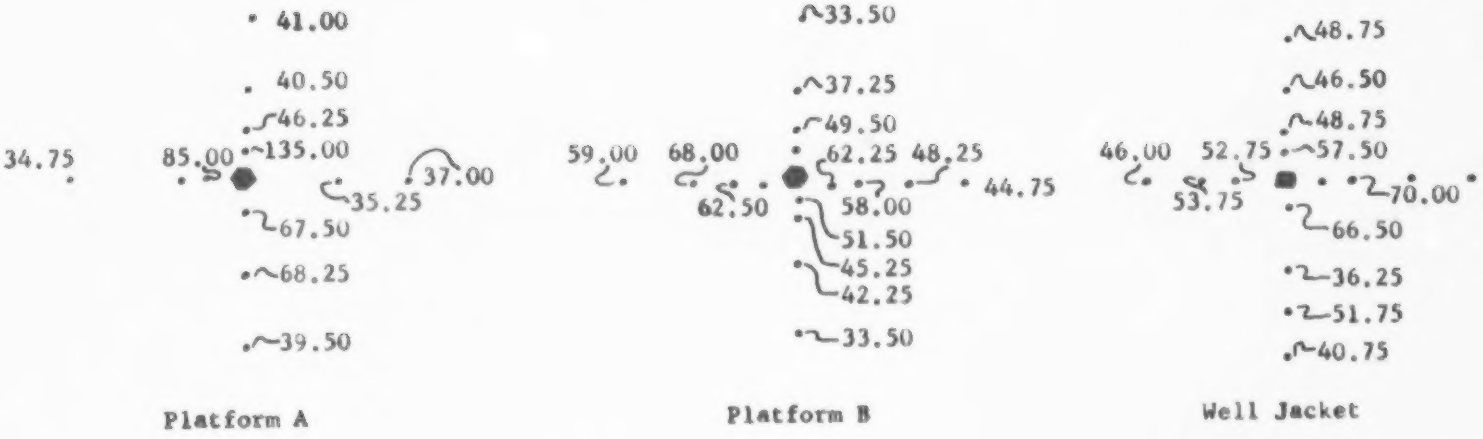

41.00
40.50
46.25
135.00
34.75
85.00
37.00
35.25
67.50
68.25
39.50
Platform A
33.50
37.25
49.50
59.00
68.00
62.25
48.25
44.75
62.50
58.00
51.50
45.25
42.25
33.50
Platform B
48.75
46.50
48.75
46.00
52.75
57.50
70.00
53.75
66.50
36.25
51.75
40.75
Well Jacket

Figure 18

Ba concentrations (in ppm) in sediment samples from ~~field stations~~.

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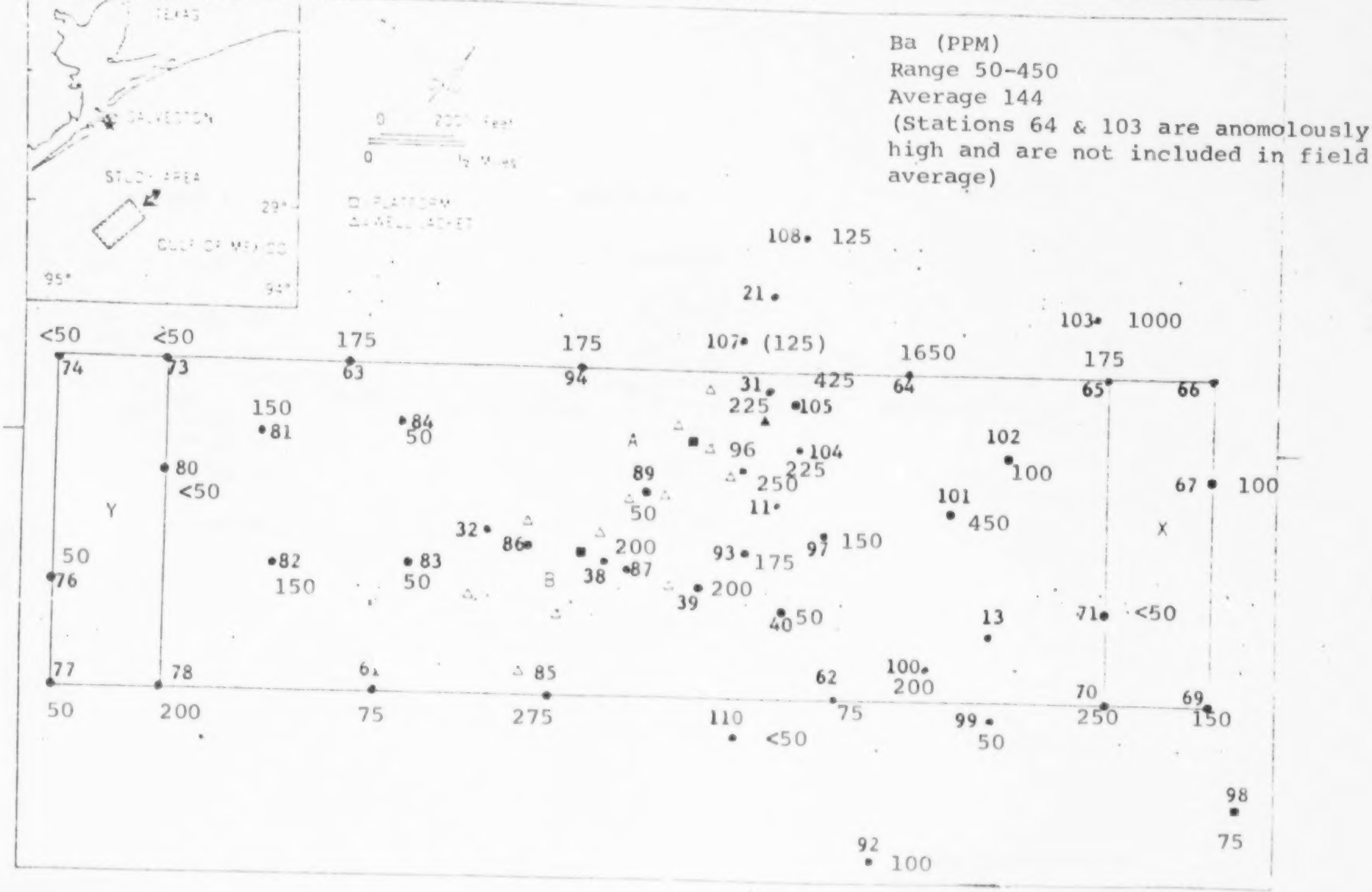
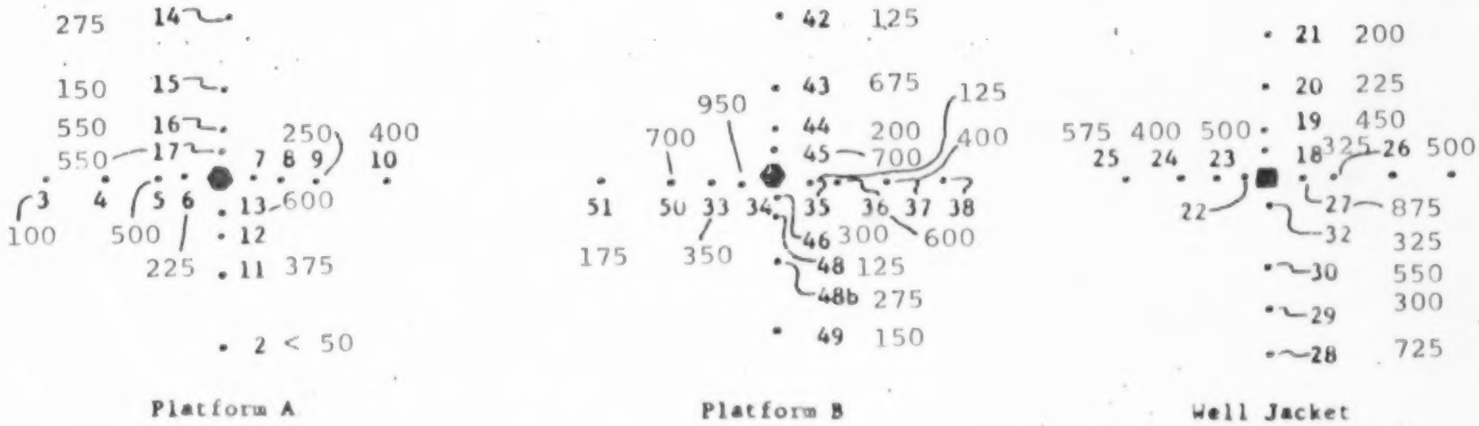

TEXAS
GALVESTON
STUDY AREA
29°
GULF OF MEXICO
95°
94°
0 2000 Feet
0 ½ Miles
PLATFORM
WELL JACKET
Ba (PPM)
Range 50-450
Average 144
(Stations 64 & 103 are anomolously high and are not included in field average)
108 125
21
103 1000
<50 74
<50 73
175 63
175 94
107 (125)
31 225
425 105
1650 64
175 65
66
150 81
84 50
80 <50
A
96
104 225
250
102 100
67 100
89 50
11
101 450
Y
32
86
200
93 175
97 150
X
50 76
82 150
83 50
38
87
B
39 200
40 50
13
71 <50
77 50
78 200
61 75
85 275
62 75
100 200
70 250
69 150
110 <50
99 50
98 75
92 100

Figure 19

Ba concentrations (in ppm) in sediment samples from stations within 375 feet of platforms A and B and well jacket

Ba (PPM)
Field Average 144


275
14
150
15
550
16
550
17
250
400
7 8 9
10
3
4
5 6
13
600
100
500
12
225
11
375
2 < 50
Platform A
42
125
43
675
950
125
700
44
200
45
700
400
51
50 33 34
35
36 37 38
46
300
600
175
350
48
125
48b
275
49
150
Platform B
21
200
20
225
575
400
500
19
450
25
24
23
18
325
26
500
22
27
875
32
325
30
550
29
300
28
725
Well Jacket

Station Spacings 25, 75, 175 and 375 feet
Station 28 - 675 feet from Well Jacket

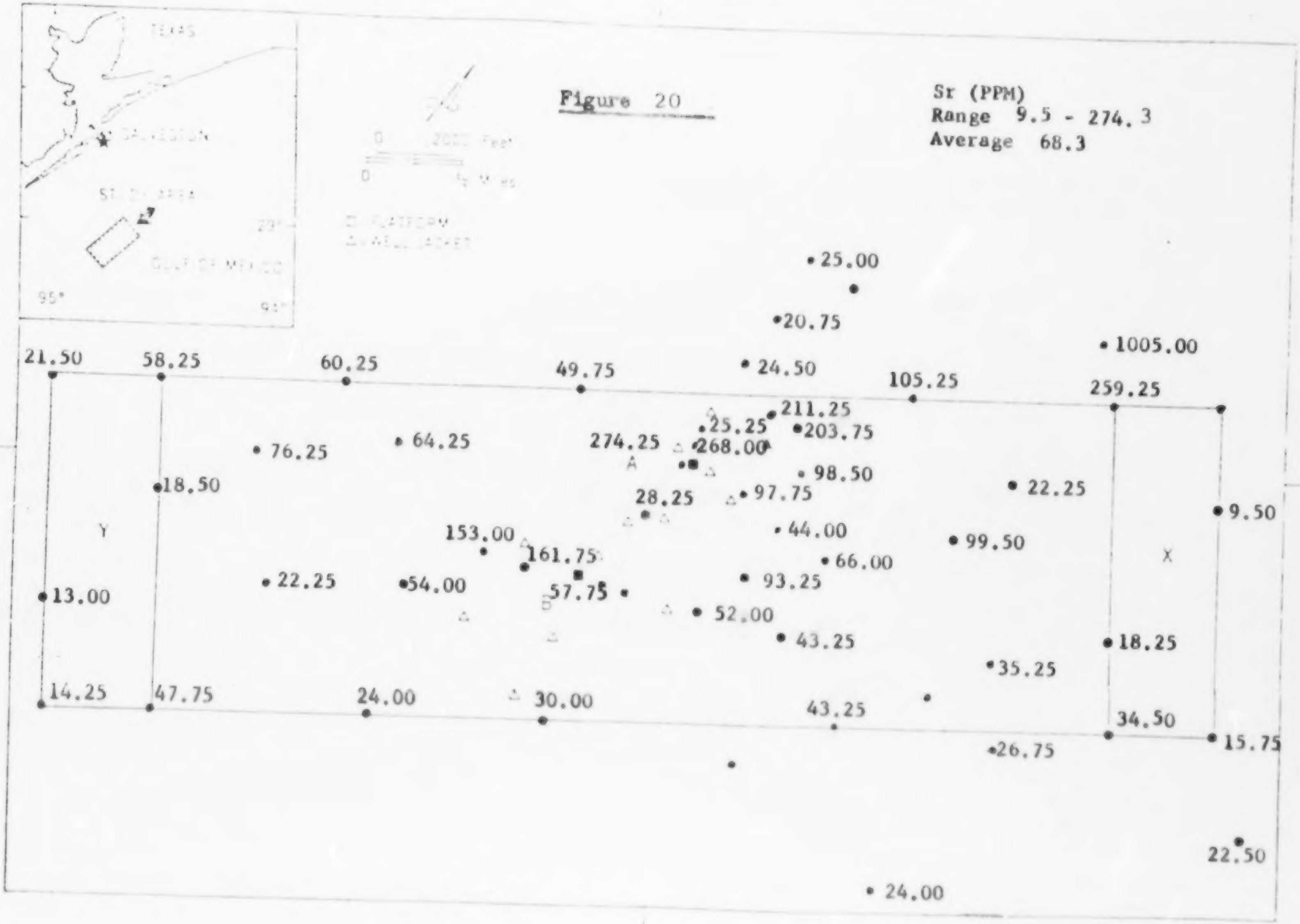


Figure 20

Sr (PPM)
Range 9.5 - 274.3
Average 68.3

TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0 2000 Feet
0 ½ Miles
□ PLATFORM
△ WELL JACKET
25.00
20.75
1005.00
21.50
58.25
60.25
49.75
24.50
105.25
259.25
211.25
25.25
203.75
76.25
64.25
274.25
268.00
A
98.50
18.50
97.75
28.25
22.25
9.50
Y
153.00
44.00
99.50
X
161.75
66.00
13.00
22.25
54.00
93.25
57.75
B
52.00
43.25
18.25
35.25
14.25
47.75
24.00
30.00
43.25
34.50
15.75
26.75
22.50
24.00

Figure 21

Sr (PPM)
Field Average 68.3

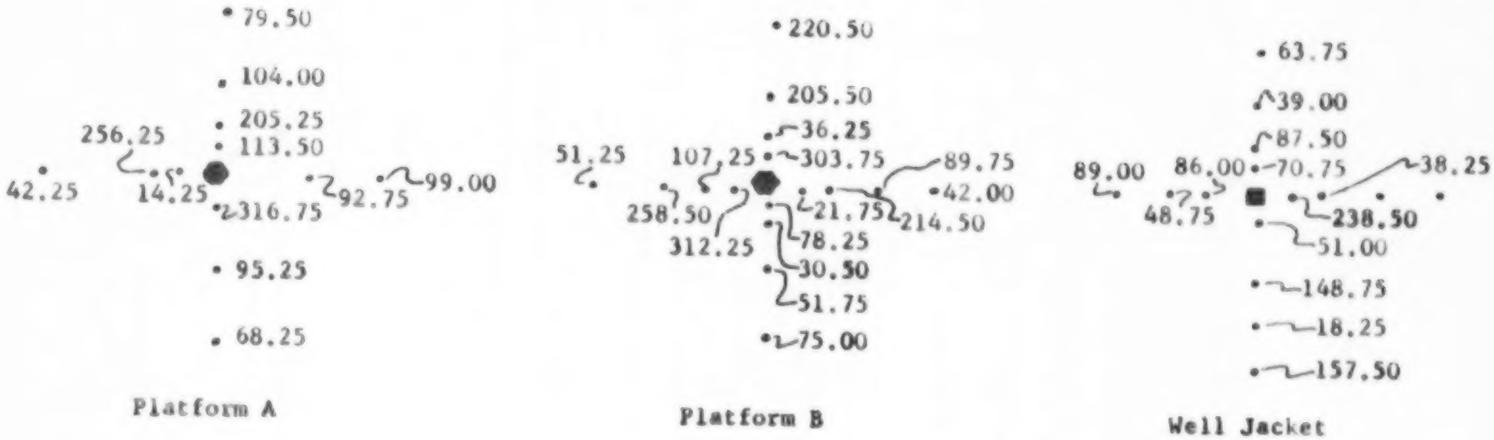

79.50
104.00
205.25
113.50
256.25
42.25
14.25
316.75
92.75
99.00
95.25
68.25
Platform A
220.50
205.50
36.25
51.25
107.25
303.75
89.75
42.00
258.50
312.25
21.75
214.50
78.25
30.50
51.75
75.00
Platform B
63.75
39.00
87.50
89.00
86.00
70.75
38.25
48.75
238.50
51.00
148.75
18.25
157.50
Well Jacket

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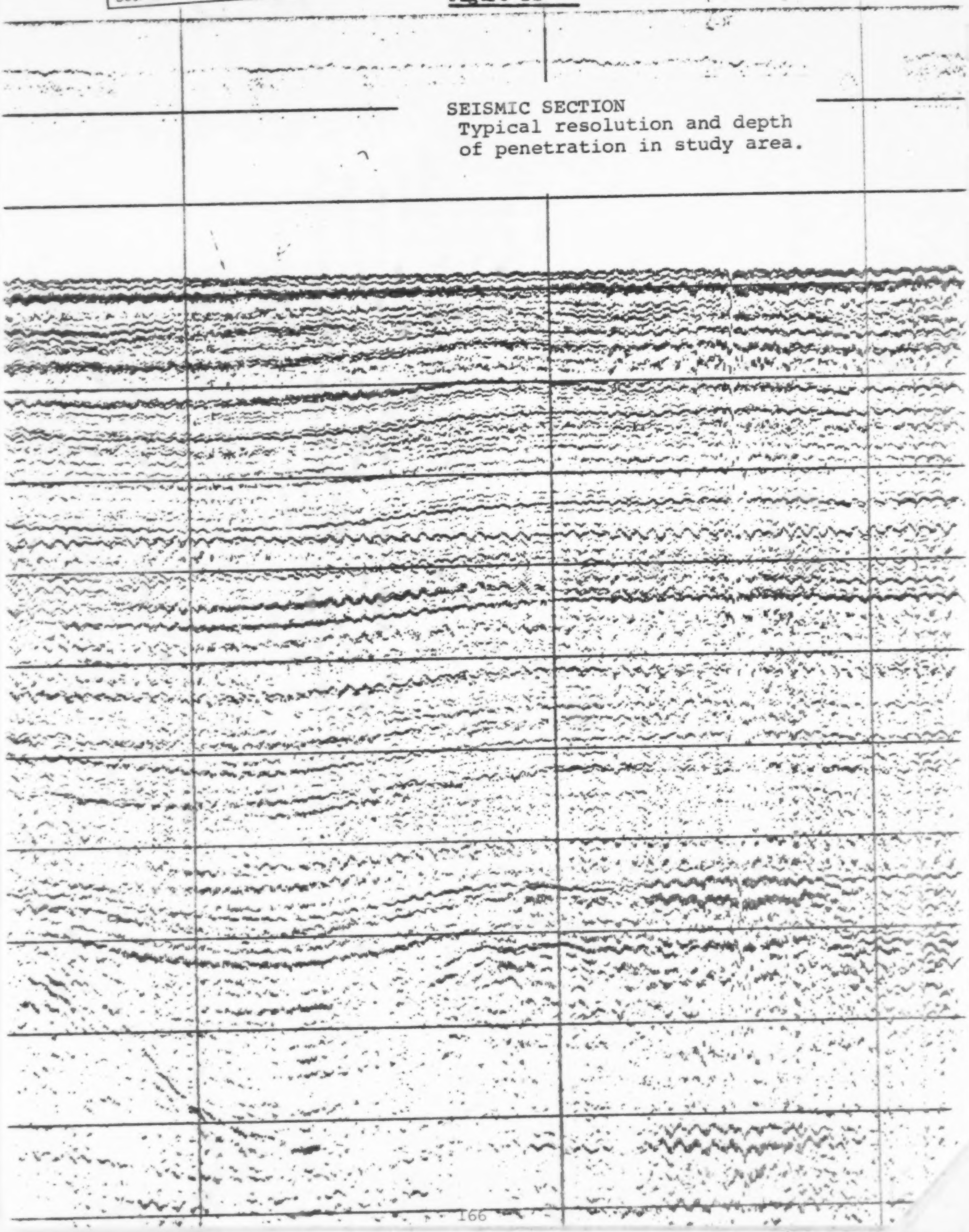
Figure 22



SEISMIC SECTION
Typical resolution and depth
of penetration in study area.

Figure 23

CONTOURED SURFACE OF DEEP SEISMIC REFLECTOR
(depth below seafloor)

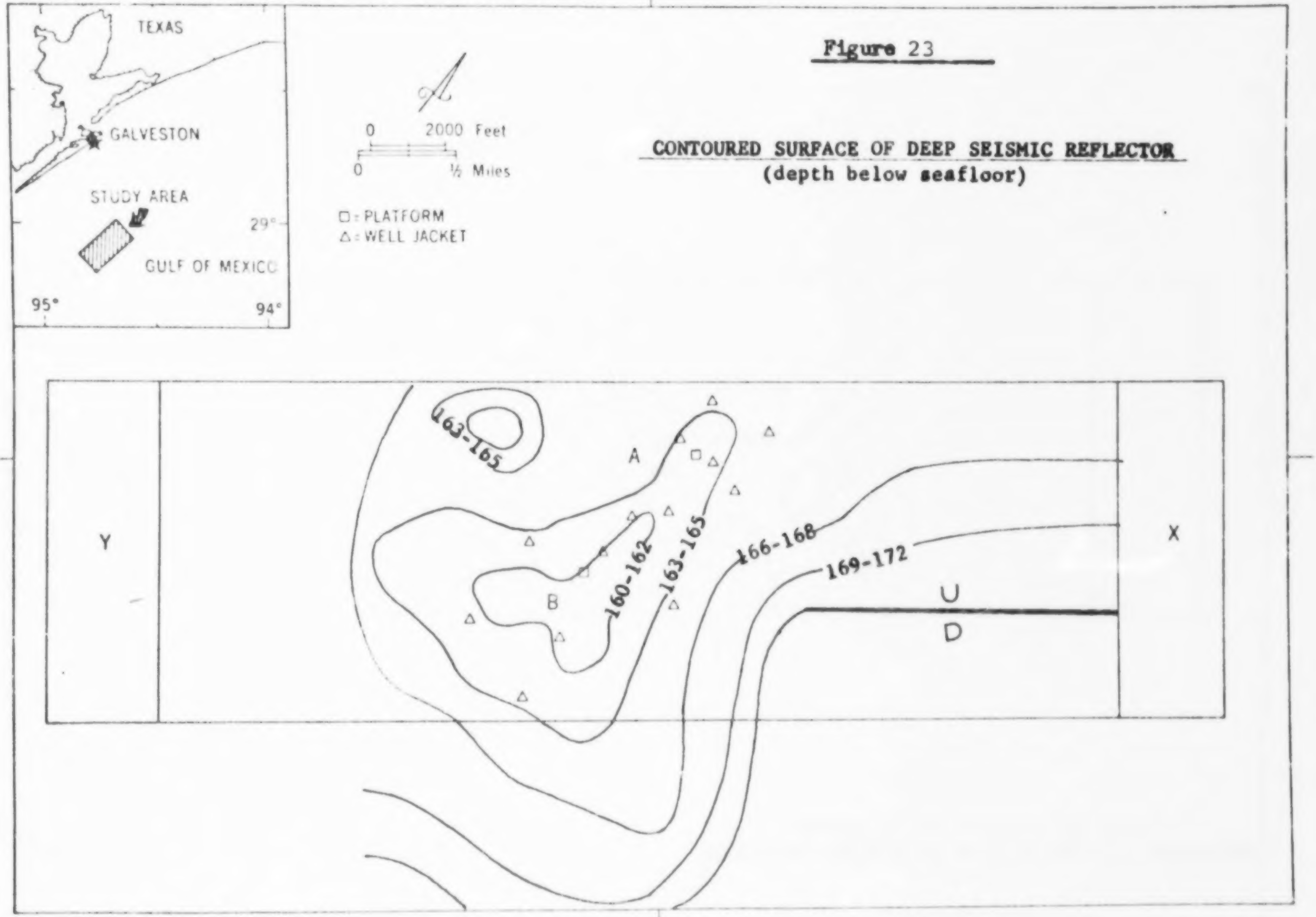
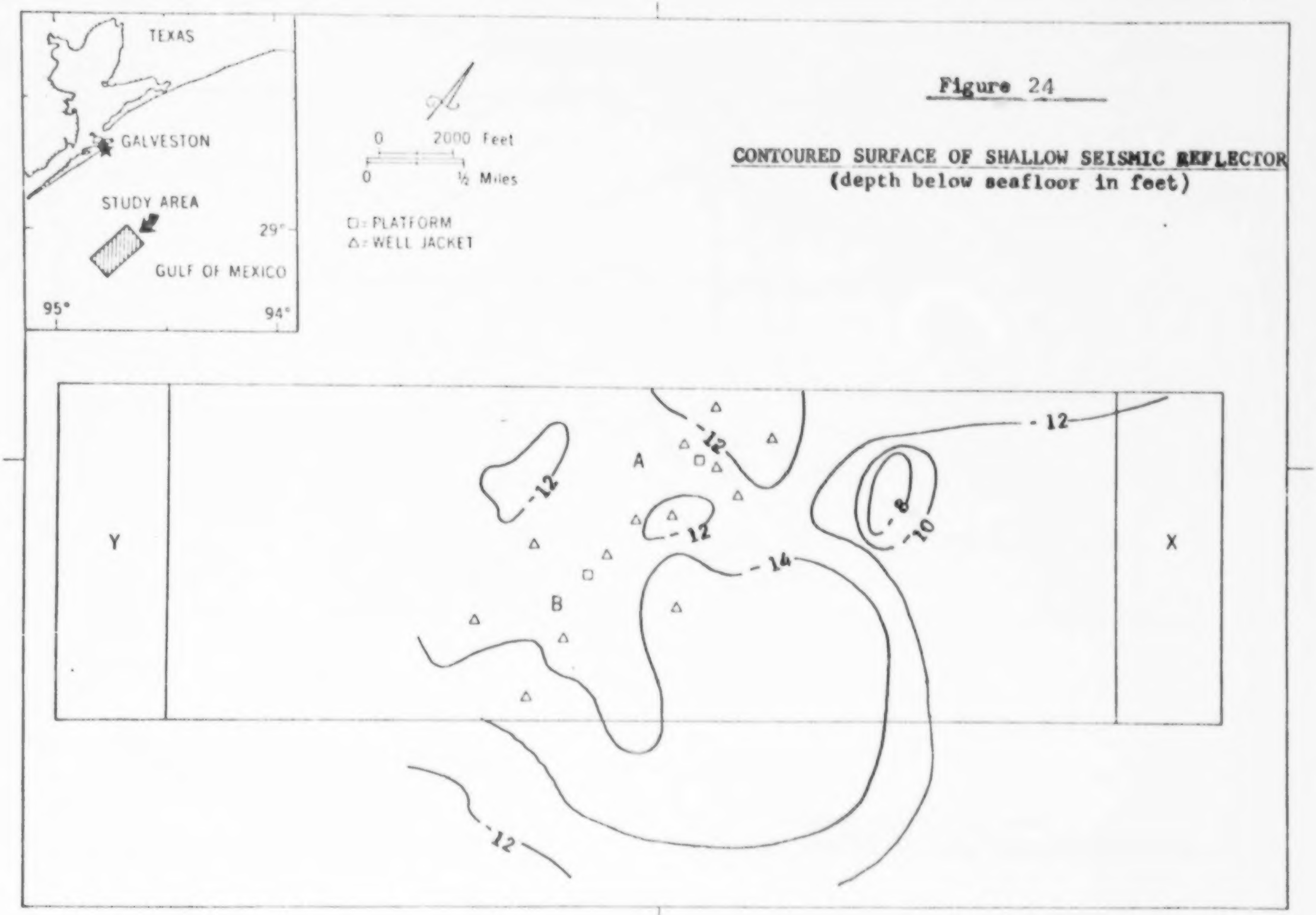

TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0 2000 Feet
0 ½ Miles
□ = PLATFORM
△ = WELL JACKET
163-165
A
B
160-162
163-165
166-168
169-172
U
D
Y
X

Figure 24

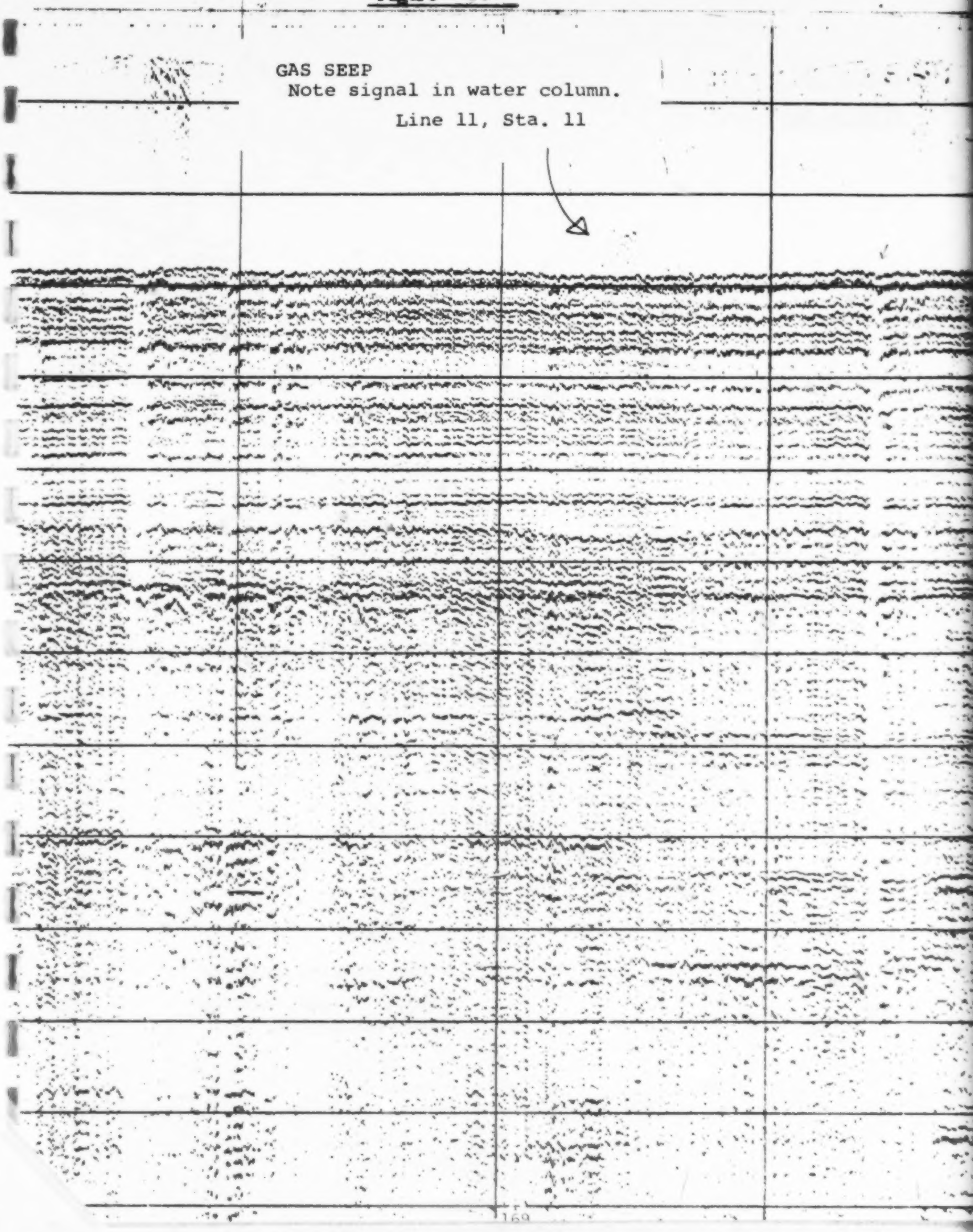
CONTOURED SURFACE OF SHALLOW SEISMIC REFLECTOR
(depth below seafloor in feet)



TEXAS
GALVESTON
STUDY AREA
29°
GULF OF MEXICO
95°
94°
0 2000 Feet
0 ½ Miles
□ = PLATFORM
△ = WELL JACKET
A
B
X
Y
- 12
- 10
- 8
- 14

Reproduced from best available copy.

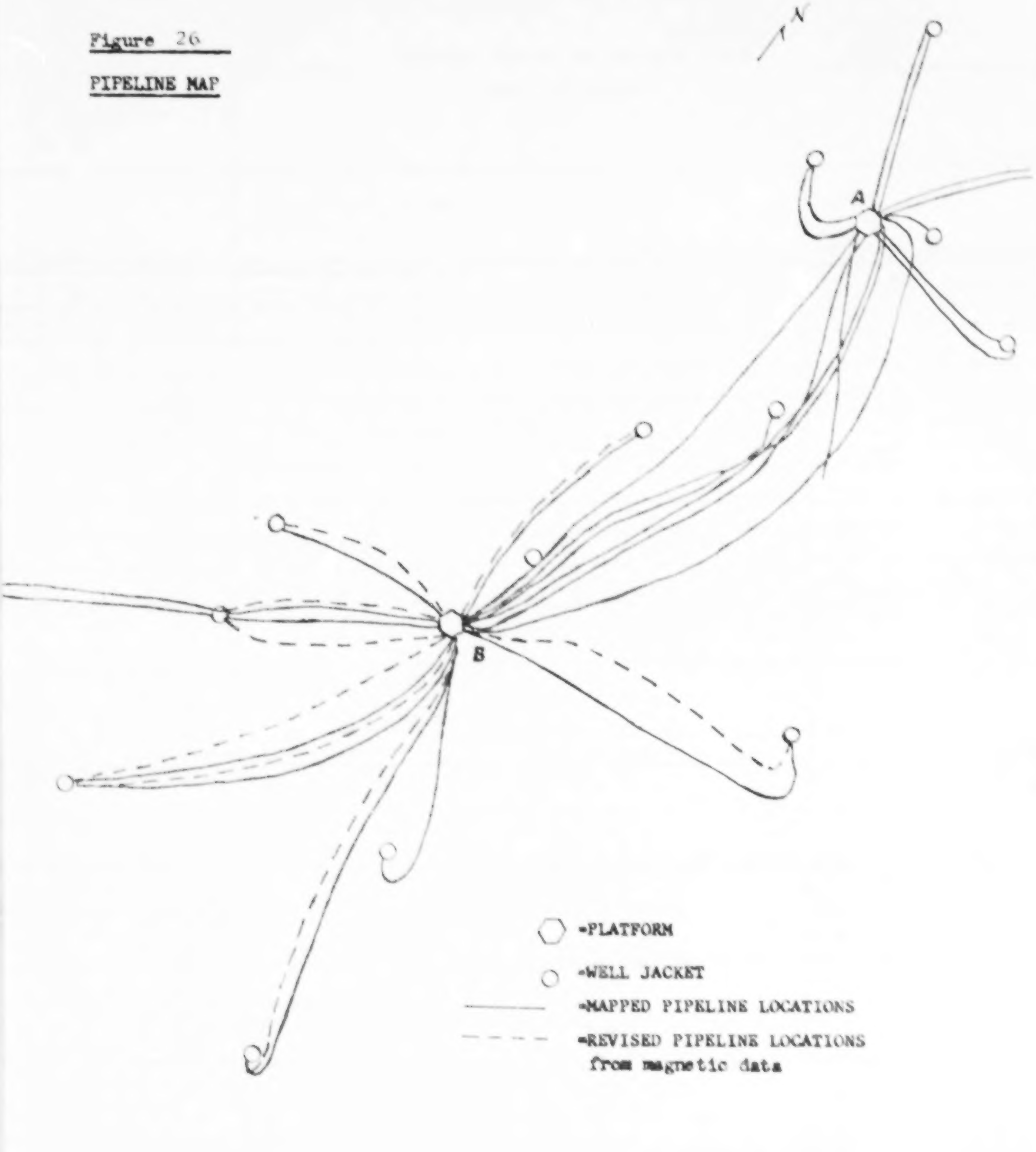
Figure 25



GAS SEEP
Note signal in water column.
Line 11, Sta. 11

Figure 26

PIPELINE MAP


N
A
B
=PLATFORM
=WELL JACKET
=MAPPED PIPELINE LOCATIONS
=REVISED PIPELINE LOCATIONS from magnetic data

Reproduced from best available copy.

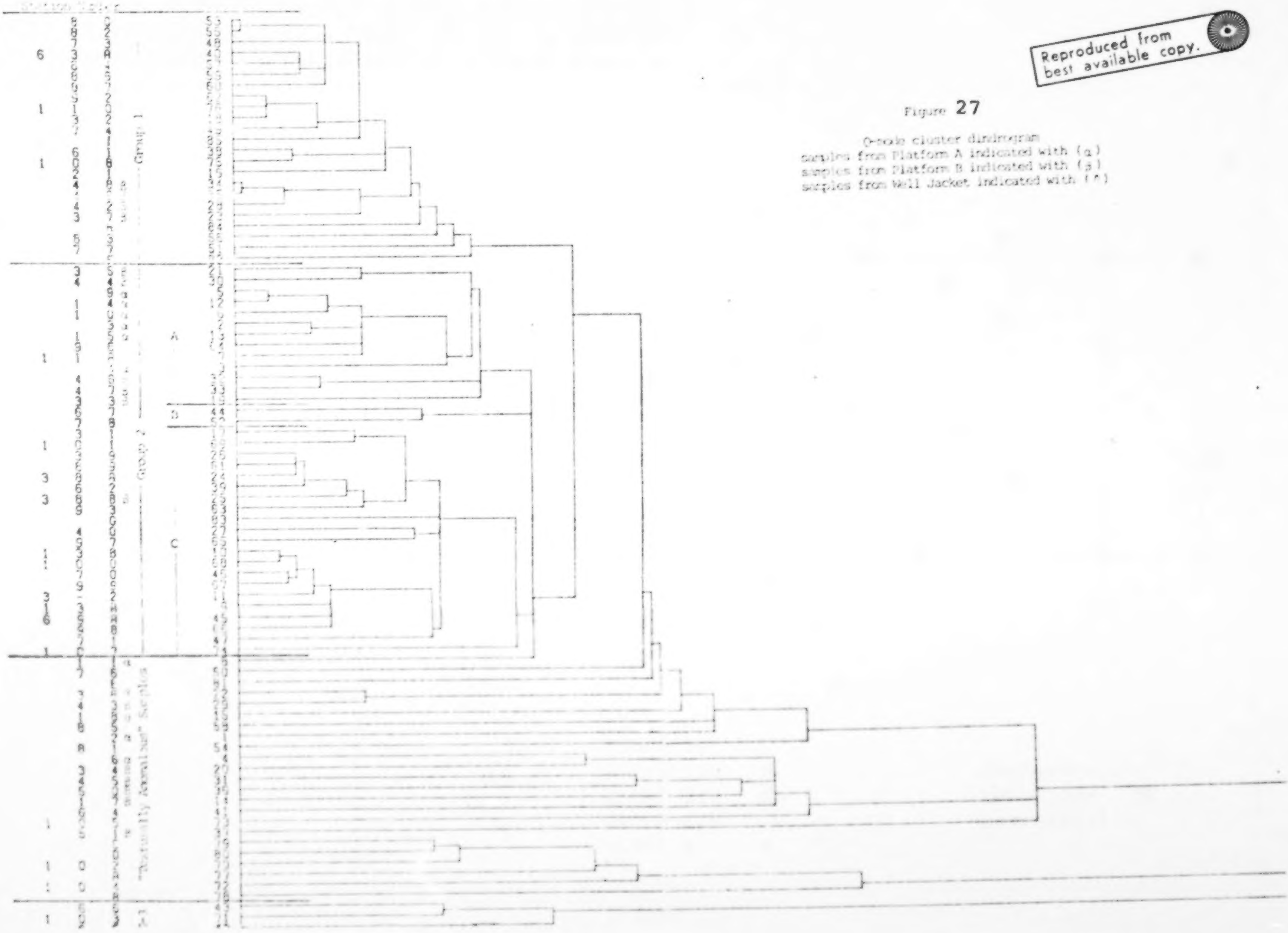
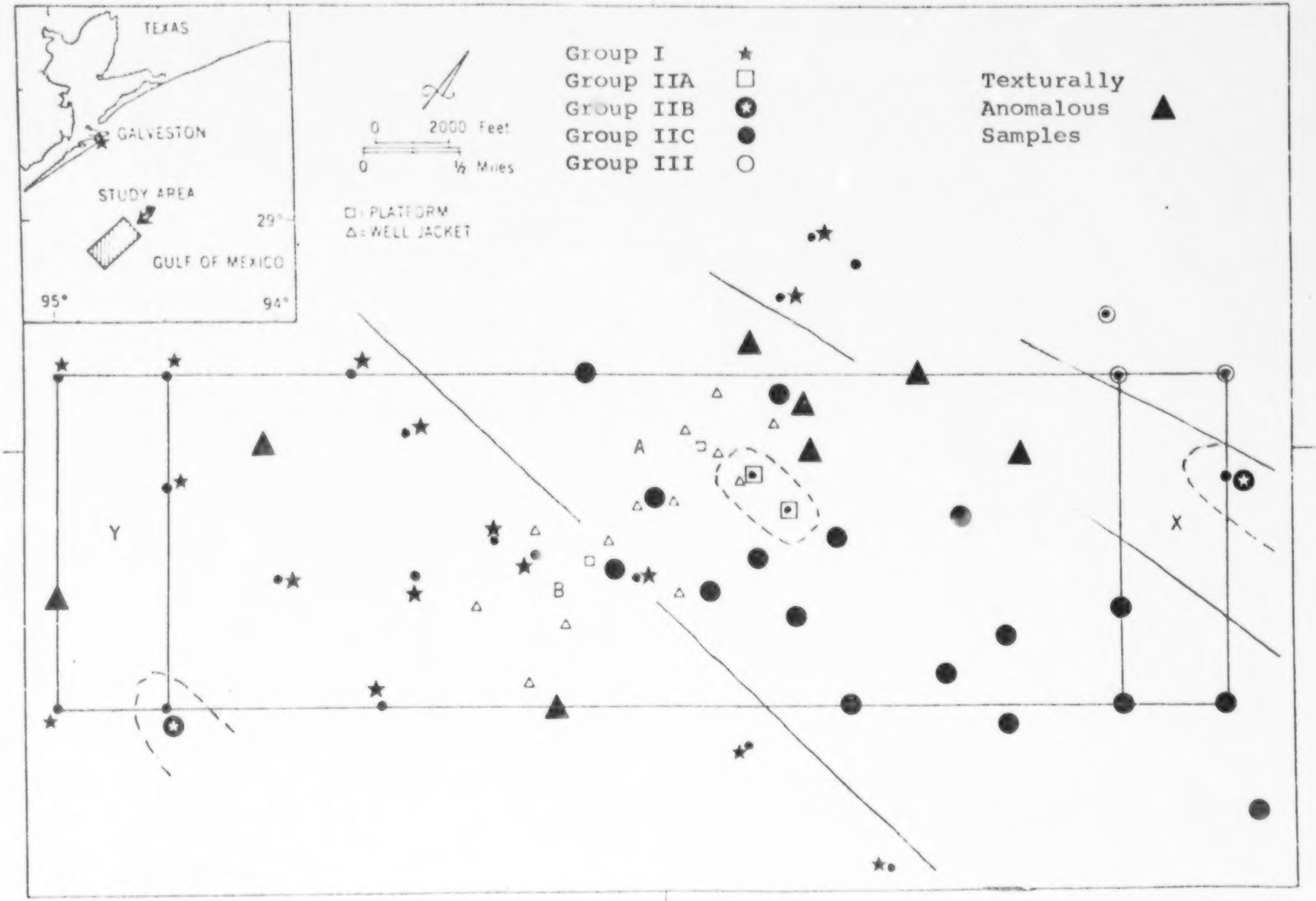


Figure 27

Q-mode cluster dendrogram
samples from Platform A indicated with (α)
samples from Platform B indicated with (β)
samples from Well Jacket indicated with (γ)

Figure 28


TEXAS
GALVESTON
STUDY AREA
29°
GULF OF MEXICO
95°
94°
0 2000 Feet
0 ½ Miles
□ = PLATFORM
△ = WELL JACKET
Group I ★
Group IIA □
Group IIB ✪
Group IIC ●
Group III ○
Texturally Anomalous Samples ▲
A
B
X
Y

Geographic distribution of samples based on Q-mode dendrogram (Fig. 2.3-22) of sedimentological parameters (sands, silt, and clay) (Fig. 2.3-22)

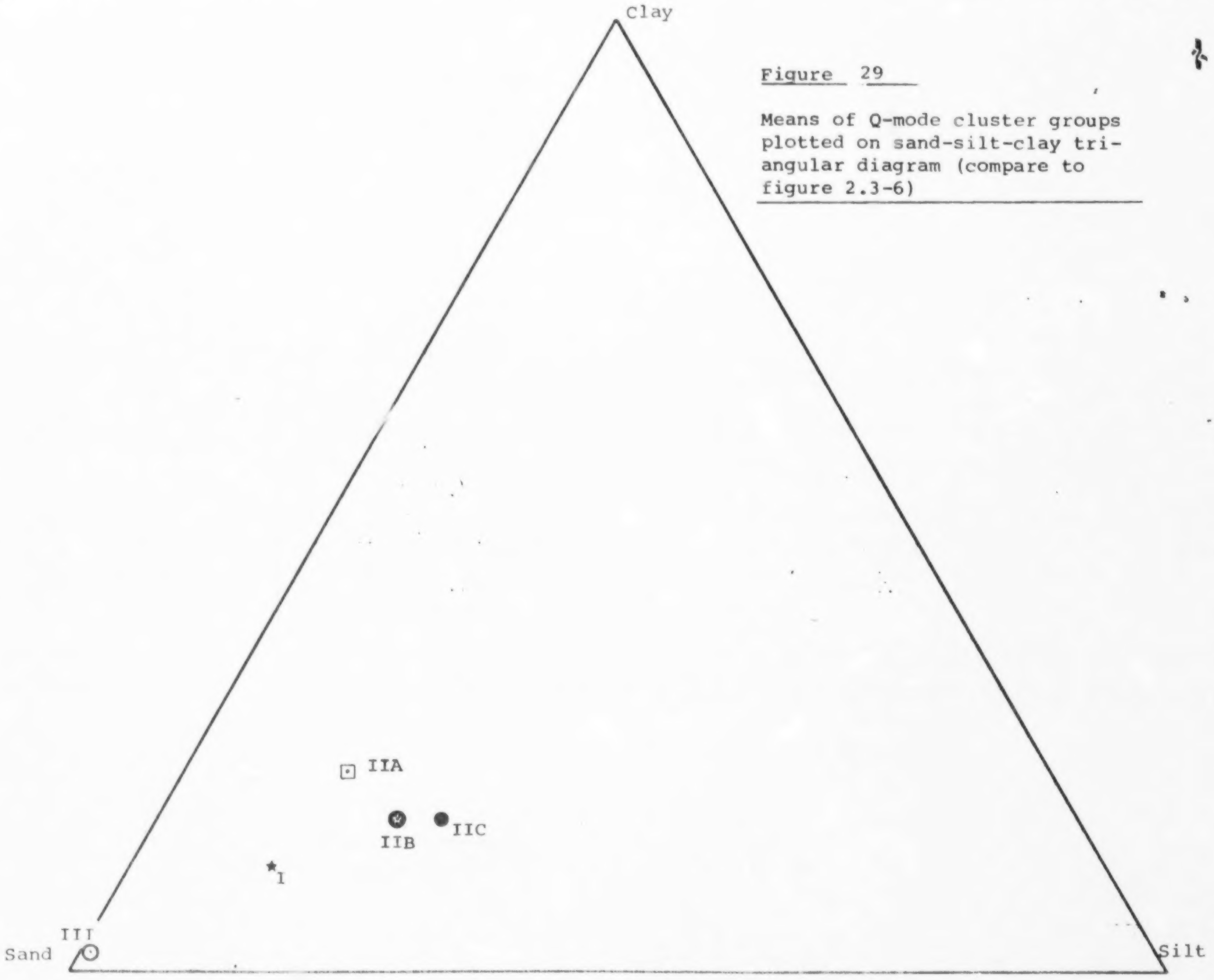


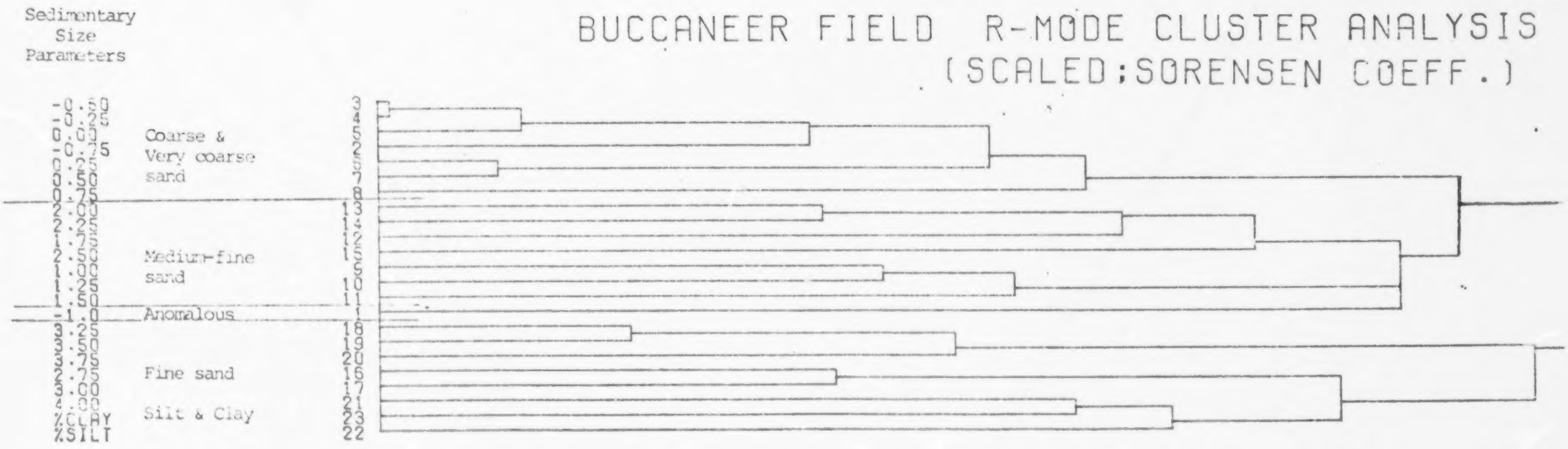
Figure 29

Means of Q-mode cluster groups plotted on sand-silt-clay triangular diagram (compare to figure 2.3-6)

Figure 30

R-Mode Cluster Dendrogram

*



*

DISTRIBUTION AND ABUNDANCE OF MACROBENTHIC AND MEIOBENTHIC ORGANISMS

Principal Investigator

Donald E. Harper, Jr.

EXECUTIVE SUMMARY

The macrobenthic populations inhabiting the bottoms in and around Buccaneer Oil/Gas Field have been sampled quarterly for one year. The data show that the average populations in the immediate vicinity of Platforms A and B were depressed compared with most of the remainder of the study area. The total number of species collected around the platforms was high, but few species were common to three or four of the collections, indicating a high turn over rate. Numerical analysis produced a site group consisting of stations in proximity to the platforms. This site group was characterized by smaller populations of the ubiquitous species and a group of seven species which occurred more frequently and in greater numbers than elsewhere in the field.

The possibility of toxic substances, sediment characteristics and predation as causes of the depression are discussed.

There was no indication of depressed populations in proximity to any well jacket investigated.

Enriched populations were found 1000 to 2000 m north and east of Platform A and 1000 m west, north and east of Platform B. The species composition of these populations was similar to that in most of the remainder of the field. These data are compared with similar findings in a study of the effects of bleedwater discharge in Trinity Bay, Texas.

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INTRODUCTION

With the increasing need for energy self-sufficiency, the United States has initiated an extensive search for hydrocarbon reserves. A possible consequence of energy production related activities is an impact of unknown magnitude on the marine environment.

The Texas continental shelf has not been as extensively exploited as the Louisiana shelf and is still a relatively unimpacted area. But as the search for oil and gas increases, Texas shelf waters will be increasingly subjected to exploration, drilling and production activities. One means of determining the possible impacts of future activities is by studying an existing offshore oil field. The Buccaneer Field is ideal for this type of study. The field has been producing both oil and gas for 11 years. The oil and gas are processed for transmission to shore at separate platforms, allowing a comparison of the effects of the two facilities. The field is geographically isolated from other fields. It is far enough from Galveston to be outside much of the sphere of influence of Galveston pollution, yet near enough to begin sampling cruises on short notice when weather permits. The field and surrounding area are in shallow enough water to permit direct observations of the bottom by divers with minimal risk of diving accidents.

Buccaneer Field was selected for study based on the results of a pilot study during which the areal distributions of benthic biota, sediments, heavy metals and hydrocarbons in and around the field were investigated in November-December 1975 (Harper, Scrudato and Giam, 1976). An oil concentration of 306 parts per million (ppm) was found in the sediments adjacent to the oil separation facility, whereas background levels of about 0.5 ppm were found at all other stations. The macrobenthic population in the oiled bottom was reduced and the meiobenthic population had an inverse ratio of nematodes to foraminifera compared with other stations. There was also evidence of a depressed fauna to the northeast of the field, that may have been caused by an increasing percentage of clay in the bottom or by some aspect of the field itself. Based on the conclusions drawn by analysis of pilot study data, the National Marine Fisheries Service, Galveston, began a monitoring study in May 1976 to obtain more detailed information on the biological and abiotic characteristics of the field and its surroundings.

The objectives of the benthic portion of the study were to determine: 1) the areal and seasonal distributions of the macrobenthic and meiobenthic assemblages in and around Buccaneer Field; and 2) if the Buccaneer Field structures or associated production activities had an effect on the population size, faunal composition, or distribution of the benthic assemblages.

STUDY AREA

Buccaneer Field lies about 50 km almost due south of the south jetty lighthouse at Galveston, Texas (Fig. 1). There are two major platform structures in the field--Platforms A and B, each with an auxilary crew quarters-helipad platform--and 13 well jackets, each of which supports one or more wells (Fig. 2). Three of the 34 active wells in the field produce oil. The oil, mixed with brine when brought to the surface, is pumped into tanks on Platform A where the oil and brine density separate. The oil is then pumped to shore, while the brine, known as bleedwater, is discharged into the ocean via a pipe that terminates about 1.5 m above the air-water interface. Shell Oil Company data indicate that an average of 138 m^3 of brine was discharged per day between January 1975 and February 1976. The data also show that oil-brine separation was incomplete; the average oil content of the brine was 25.1 ppm. We twice obtained samples of the bleedwater being discharged from Platform A. The samples had salinities (measured by refractometer) of 50 parts per thousand (ppt) (10 October 1976) and 49 ppt (3 November 1976) and both had a strong oily odor. If the water was shallower, one would expect to find quantities of oil incorporated in the bottom sediments as was found in Trinity Bay, Texas (Mackin, 1971), and in Louisiana (Mackin and Hopkins, 1961). Because of the water depth in the Buccaneer Field, I suspect that the oil detected during the pilot study was the result of an accidental spill. The sea floor around Platform A was examined numerous times by divers after the pilot study samples were collected and no obvious trace of oil was found. However, Mr. Richard McGaffey, Galveston, informed me orally that he has periodically observed oil on the sediments while diving around Platform A.

FIELD METHODS

Transects were established radiating from Platforms A and B (Fig. 2). Stations on the transects were located close together near the platforms and at increased inter-station distances away from the platforms. The rationale for this design was that if there was an environmental stress associated with the platforms, it would be manifest relatively close to the platforms and would decrease with distance from the platforms. This method was used successfully by Mackin (1971) to study the effects of bleedwater being discharged into Texas estuaries. Buccaneer stations were concentrated to the north and east because pilot study data indicated a possible depressed fauna to the northeast and because the strongest bottom currents flow to the northeast (see abiotic data).

Transect A passed through Platform A on a 83° (true) course. Transect B had two legs; the northern leg ran 353° from Platform A and the southern leg ran 187° from Platform A to Platform B. Transects C and D began at Platform A and ran 34° and 109° respectively. Transect E passed through Platform B on a course of 64°. Around Platform A transect stations were located on concentric rings 15, 50, 100, 1000 and

2000 m distant from the platform. The south leg of Transect B had an additional station at 500 m. Beyond 2000 m from the platforms, there was no regular station spacing. The sampling effort was concentrated near Platform A and there were relatively few stations in proximity to Platform B. Radar fixes on Platforms A and B were used to determine sampling station locations. Station numbers and distances from Platforms A or B are listed in Table 1.

A quarterly sampling program was conducted; collections were made in July and October-November 1976, and January-February and April 1977. The October-November and January-February collections were protracted because of bad weather and it is possible that natural population changes occurred between the times of the first and last cruises.

The benthos were sampled in triplicate by divers who pushed Ekman grabs into the sediment, triggered them and secured the jaws and vent flaps with elastic bands. The maximum penetration depth of the grabs was 15 cm; the actual sample depth depended on the consistency of the substrate. The diving method of sampling was quite efficient. The boat did not have to be anchored, and sampling could be completed in 5 minutes. While on the bottom, the divers also collected a water sample, observed the characteristics of the substrate and noted the presence of macrofauna not likely to be sampled by the grab.

When the samples were returned to the vessel, a meiofaunal subsample was taken from each benthic sample with a 2.54 cm diameter plastic tube. The meiofaunal samples were preserved intact in 5% seawater formalin. The macrofaunal samples were washed on a 0.5 mm mesh sieve to remove fine sediments. The organisms and shell hash retained on the sieve were preserved in 5% seawater formalin.

Abiotic data collected at each station included surface and bottom water temperature and salinity, sediment temperature and a visual analysis of the sediment composition. Temperature was measured with a Celsius thermometer, salinity with a refractometer.

LABORATORY METHODS

In the laboratory the macrofaunal samples were washed with fresh water to remove formalin. The lighter organisms were separated from the shell hash by repeated decanting and were preserved in 70% ethanol. Protein specific rose Bengal stain in 70% ethanol was added to the shell hash to aid in the detection of remaining organisms. After at least 24 hours, the shell hash was examined microscopically and all organisms were removed and combined with the decanted material. The organisms were sorted, identified to the lowest possible taxonomic rank and counted. Because initial sample analyses were performed by several persons, I examined all samples to correct misidentifications or at least to standardize taxonomic errors.

The meiofaunal samples were washed on 0.5 and 0.063 mm (63μ) mesh sieves. Each 0.5 mm fraction was returned to the appropriate macrofaunal sample. Meiofaunal organisms retained on the 63μ sieve were removed from the sediment by floatation with a saturated sucrose solution and preserved in 70% ethanol-rose Bengal stain. These organisms were identified to the lowest possible taxon and counted.

DATA ANALYSIS

The temperature and salinity values recorded during each 1 or 2 day cruise were averaged. The averaged values were used to describe temperature and salinity trends, and unless otherwise indicated, the discussions herein will refer to averaged data.

The Ekman grab sampled an area of 232.26 cm^2; multiplication by a factor of 43 extrapolated raw data to numbers of individuals per m^2. The meiofaunal core tube had a cross-sectional area of 5.067 cm^2; multiplication by a factor of 1972.39 will extrapolate raw data to numbers of individuals per m^2.

The biological data were examined descriptively, comparing diversity and population size between stations for all collections combined and for each quarterly sampling period. The macrobenthic data were also subjected to computer analysis following the methods most recently described by Clifford and Stephenson (1976) and Smith (1976). Analyses were done using the Bray-Curtis dissimilarity measure and flexible sorting with data that had been transformed with either a $\sqrt{n}$ or $\sqrt[3]{n}$ transformation (a log transformation was also done on the combined data, but was considered too severe and was rejected). Infrequently occurring species were eliminated prior to data analysis.

ABIOTIC CHARACTERISTICS OF THE STUDY AREA

Temperature

The water depth in the field is sufficiently shallow (19-20 m) to allow complete overturn during fall cooling but the bottom water temperature will probably lag behind the surface water temperature during most spring warming periods (cf. Temple, Harrington and Martin, 1977).

The winter of 1976-77 was unusually cold in the Galveston area as it was in much of the eastern and central United States. The mean monthly water temperature trend in the Galveston Channel, January 1976 through February 1977, is presented in Figure 3 and compared with the monthly mean trend for the period 1922-1975 (National Ocean Survey records). The 1976 water temperature was near average from January through May and was slightly cooler (< 1.5 C) than average from July-September. In October and November, however, the water temperature decreased much more rapidly than usual and was 4-6 C cooler than average. Below average temperatures continued through February 1977; the mean temperature in January (the coldest month) was about 4.6 C cooler than average.

The above data, while not directly comparable with offshore water temperatures, do indicate the water temperature trends of the area prior to and during the study. The water temperatures recorded in the vicinity of Buccaneer Field by the biological field crew and by Martin (1978), are shown in Figure 4. In 1976, the water temperature increased between May, when the study began, and August. By late September the temperature had begun to decrease; National Ocean Survery air temperature records indicate that a series of cold waves passed through Galveston in October and November coincident with the rapid cooling of both Galveston Channel and offshore waters. The lowest recorded water temperatures, about 12 C, occurred between mid-January and early February 1977. The temperature began to increase in mid-February and rose rapidly through April when sampling ceased. The sediment and bottom water temperature trends were virtually identical during most of the study. During the spring warming period (February-April), the surface water warmed more quickly and was 2-3 C warmer than the bottom water or sediment.

On 22 July 1976, one abnormal set of temperature data were recorded. Six stations north and east of Platform B had bottom water temperatures 3 C cooler than other stations sampled that day. These stations were not all sampled consecutively, so thermometer reading error was not to blame. The cause of these lower temperatures is not known.

Salinity

The salinity trends present during the study are shown in Figure 5. In general, the bottom water salinity fluctuated repeatedly between 32 and 36 ppt. The surface salinity was depressed in May when sampling began, but increased rapidly and the water was nearly isohaline during most of the study. In April 1977, the surface salinity appeared to be decreasing. Temple, Harrington and Martin (1977) also recorded surface salinity decreases in the spring months (May-June) that they attributed to freshwater discharge from both the Mississippi River and local rivers.

Sediments and Bathymetry

Data collected during the pilot study (Harper, Scrudato and Giam, 1976) and during the present study (Anderson, Schwarzer and Clark, 1978) indicated sediments in the study area graded from sand-silt-clay in the northeast through silty sand and sand to clayey sand in the southwest (Fig. 6). These geological nuances were not readily apparent to the biologist/divers who classified most of the study area sediments as muddy sand with shell hash. Around Platform A the bottom consisted of hard clay (Beaumont Clay?) that was difficult to sample and was littered with metal debris (pieces of catwalk, gears, pipes, welding rods, etc.).

The water over most of the study area was about 19-20 m deep. Proceeding north from Platform A to station 109, the bottom graded from soft muddy sand in 19 m depth to hard sand in 16 m depth. About mid-way between stations 108 and 109 was a ridge, the crown of which was about 12 m deep. To the north-northeast of Platform A was an area of gravel-sized, coarse, brown shell fragments in 16 m depth (Fig. 6); station 103, established in this area, was abandoned because of its quite different substrate and fauna. The bottom adjacent to Platform B was littered with metal debris also, and the sediments were hard sandy mud. A shelly bottom was present a short distance to the southwest of Platform B.

There is evidence that the loose sediments are periodically removed and subsequent redeposited or are redistributed by currents and/or waves. The sediments at station 12, to the east of the field, were soft muddy sand in July and October, but hard clay was exposed in January and April. This was the same area where exposed, hard clay was collected during the pilot study in December 1975. Also, seismic records detected a structural offset that extended from the vicinity of Platform A through the northeast edge of the study area (Anderson, Schwarzer and Clark, 1978). This offset was seen in January only; divers reported the presence of a 15 cm high scarp in the vicinity of station 8. It is possible that during relatively calm parts of the year, finer sediments may accumulate and then be removed during the stormy winter months. After a period of heavy seas, the divers reported zero visibility on the bottom. On several occasions, the seas became more turbulent while the field crew was sampling, and visibility, which was excellent early in the day, was reduced by the end of the day.

Hydrocarbons and Organic Carbon

With the exception of one pilot study station (Harper, Scrudato and Giam, 1976) the sediments contained primarily biogenic hydrocarbons. There were no clearly defined concentration gradients, although high levels of n-alkanes were found to the north and east of Platform A (Middleditch, Basile and Chang, 1978). The sediments at station 21 (north of Platform A) contained high total organic carbon levels (Behrens, 1977).

Wind, Waves and Currents

Wind generated waves and currents are the agents most probably responsible for redistribution and/or transportation of sediments in the Buccaneer Field area. Two principal wind regimes dominate the Texas coastal area. These include southeasterly winds that blow persistently from March through November (annual average of 50% of the time) at an average speed of 5.7 m/sec, and short-lived northerly winds associated with cold waves from December through February (annual average of 30% of the time) at an average speed of 6.7 m/sec. Northerly winds with speeds of up to 22 m/sec that accompany cold waves can generate offshore waves in excess of 3.5 m high (Fisher et al., 1972; SEADOCK, 1975).

The seas are generally calm in the summer and fall and moderate in winter and spring; waves greater than 2 m in height occur only 20% of the time. Wave periods are less than 8 seconds 80% of the time. Waves with periods of 5.1 seconds will feel bottom in the Buccaneer Field area. Wind speeds necessary to produce these wave periods, 9.1 m/sec, occur less than 25% of the time; summaries of wind data recorded at the Buccaneer Platform (September 1970-August 1972) indicated that winds in excess of 8.6 and 10.8 m/sec occurred from the northeast through the southwest 25% and 9% of the time respectively. The annual average wind speed was 7.0 m/sec, almost 2.5 m/sec faster than was recorded over Galveston (SEADOCK, 1975).

Current data from the Buccaneer Field were obtained from current meters installed near the surface (4 m) and bottom (17 m) of the water column at the Buccaneer Platform. During the period 25 October 1971 through 30 August 1974, surface currents were predominantly westward in March through June and easterly in July through September. Surface current speeds in excess of 50 cm/sec occurred most often between May and August. Bottom currents were predominantly easterly in July, August, November and December. The strongest easterly bottom currents occurred in July and August with speeds greater than 25 cm/sec 40% of the time and greater than 50 cm/sec 15% of the time. The strongest westerly currents occurred in April with speeds greater than 25 cm/sec 20% of the time (SEADOCK, 1975).

Data compiled by the Bureau of Land Management (1977) also indicated southerly winter and northerly summer surface currents along the northern Texas coast Decreased spring surface salinities occurred off the Texas coast 1.5 to 2 months after peak Mississippi River discharge, indicating a westward current flow (Temple, Harrington and Martin, 1977).

Daily current records from the Buccaneer Platform in August, September and December 1973 indicated that flow reversals occurred frequently at both the surface and bottom of the water column and that the bottom current was often flowing 180° relative to the surface current direction. The surface currents appeared to be responding to both wind stress and tides (SEADOCK, 1975).

RESULTS AND DISCUSSION

Macrobenthic Populations and Diversity

About 82,700 individuals (raw numbers) were collected during the study. The exact number of species is difficult to deduce because in many cases young specimens could not be identified and were recorded as a separate species even though the adult might have been known. I estimate that between 400 and 420 species were collected (Appendix Table A1).

In the following sections, seasonal and areal population distributions are described. Unless otherwise stated, it will be understood that the terms "populations" and "individuals" refer to the average number of individuals/m^2 per station. The macrobenthic data from each station are not included with this report, but may be obtained from the National Marine Fisheries Service, Galveston, or from the National Fisheries Engineering Laboratory, National Space Technology Laboratory Station, Bay St. Louis, Mississippi.

Seasonal Trends

Populations - The average quarterly number of individuals per station (data in Appendix Table A2) is compared with the sediment temperature trend in Figure 7 (some temperature data points have been inferred from bottom water temperatures). The populations decreased between July and January, concomitant with the temperature decrease, then increased by April as the temperature increased. This population trend resembled the benthic population trend offshore from Freeport, Texas in 1973 (Harper and Case, 1975), but the Buccaneer Field populations were almost an order of magnitude larger. Both of these trends were somewhat different from the trends of nearshore (18-27 m depth) benthic populations sampled during the South Texas Outer Continental Shelf (OCS) study (Holland, 1976). The largest OCS populations occurred in April-May, decreased by August-September and increased again slightly in December-January. The OCS populations were also about an order of magnitude smaller than the Buccaneer populations. The differences between Buccaneer and South Texas seasonal population trends may be a result of the geographic distance between the two areas, latitudinal differences (South Texas is in a more tropical climate) or annual differences in temperature trends.

Diversity - The seasonal diversity trend was similar to the population trend. The average number of species collected each quarter were: July, 53.7; October-November, 46.7; January-February, 39.2; April, 42.7. The data for each station are in Appendix Table A3.

Dominant species - The species with more than 5000 total individuals (4 collections) are listed in Table 2 with the average number of individuals per station per quarter. All of these 26 species occurred at 39 or more of the 48 stations and together accounted for 74.7% of all individuals collected. It can be seen that half of the species had peak populations in July while only one peaked in January-February. Contrary to what might be expected, January-February was not the quarter in which most species had lowest numbers of individuals; these were fairly equally distributed among the four quarters. It will also be noted in

Table 2 that although the second lowest number of individuals of many species occurred in January-February, most of these appeared to be intermediate stages in population increases or decreases between October-November and April. Thus it appears that the low January-February population was not caused by a general population decrease.

Areal Distribution

Populations - The average quarterly population at each station is shown in Figure 8 (four stations with one missing data point each were deleted). Most of the bottoms in the study area had populations of 5000-7500 individuals. Three areas had depressed populations of less than 5000 individuals. One was to the east of the field and corresponded with the area where clay was either exposed or near the surface. The other two were in proximity to Platforms A and B (inset, Fig. 8); the populations within these latter two areas were between 2200 and 3800 individuals.

There were also three areas in which the populations were larger than 7500 individuals ("enriched areas"). One was on transect B, 2000-3000 m north of Platform A, one was 1000 m east and north of Platform A on transects A and C, and one was within a 1000 m radius of Platform B (enclosing the depressed area). The second of these enriched areas corresponds with an area of high total organic carbon in the sediments (Behrens, 1977).

The distributions of populations along each of the transects are depicted in Figure 9. The depressed populations close to Platforms A and B are obvious, as are the enlarged populations away from the platforms.

The quarterly areal population patterns are shown in Figures 10-13. Although there were fluctuations in the size of the population collected at a given station, two patterns persisted through all four collections, viz: a depressed area occurred around each platform and an enriched area occurred northeast of Platform A.

In July (Fig. 10), most stations in the vicinity of the field had populations of 7000-8500 individuals. Stations 100-1000 m north and east of Platform A had populations in excess of 9000 individuals as did stations in the extreme eastern end of the study area. A broad area to the east of Platform A had depressed populations as did the stations on the west leg of transect A and most stations in the immediate vicinity of Platforms A and B; exceptions included stations 34, southwest of Platform B, and 6, west of Platform A, both of which had large populations. The population at station 6 was due to large numbers of the archiannelid *Polygordius appendiculatus*; at station 34 several species were abundant.

In October-November (Fig. 11), most stations in the study area had

5000-7000 individuals. Populations in excess of 8000 individuals were found north and northeast of Platform A and in a large area northeast of Platform B. Depressed populations (< 4000 individuals) occurred around Platforms A and B. The depressed area which occurred to the east of Platform A in July was not evident in October-November; the populations were about the same size in both quarters, but populations throughout the study area had generally decreased by October-November.

In January-February (Fig. 12), most stations had 4000-6000 individuals. One large area north and east of Platform A had populations in excess of 7000 individuals. Several stations to the east of Platform A had populations less than 4000 individuals. Divers reported that the bottom at station 12 was hard clay with no veneer of loose sediments and that sampling was difficult; only 59 individuals (raw data) were obtained, the lowest population collected during the study. A large number of unidentified young bivalves were collected in one replicate sample only at station 64, and caused the station to be included in the enriched area northeast of Platform A. If the bivalves are deleted from the data, station 64 would be included in the depressed area as it was in July.

In April (Fig. 13), most stations had 5000-8000 individuals. Populations of more than 8000 individuals occurred north and east of Platform A and north and west of Platform B. Populations smaller than 4000 individuals occurred around both platforms and to the northeast and east of Platform A, adjacent to the enriched area.

The quarterly population patterns are compared for each transect in Figures 14-18 which depict the population changes along each transect. Again the depressed and enriched areas are usually evident.

Diversity - The total number of species collected at each station over 4 quarters is shown in Figure 19. Most stations had between 90 and 110 total species, but three areas had stations with less than 85 species. The largest of these areas was composed of 5 stations on transects A and B west and north of Platform A. The second area was composed of 2 stations toward the eastern end of the study area on transect A and the third was a single station (32) on transect E, west of Platform B.

The changes in total diversity with distance from Platforms A and B are shown in Figures 20-22. The diversity was high immediately around Platform A. To the north, west and south, at distances of 1000-2000 m, were areas of decreased diversity beyond which were areas of increased diversity. The diversity was relatively constant on the eastern leg of transect A only. There was no consistent trend aroung Platform B.

Population stability - The combination of high diversity and depressed populations around Platform A suggest an unstable population with a high turn-over rate. This possibility was investigated in three ways: by calculating, for each station, the ratio of recurring species

(4 and 3 occurrences) to nonrecurring species (2 and 1 occurrences); the ratio of species occurring 4 times to those occurring once; and the ratio of species occurring 4 times to the total number of species present. All three methods gave similar results. The ratios were lower in the vicinity of Platforms A and B, and at stations 12 (exposed clay) and 109 (relatively shallow, sandy bottom). The ratios of species occurring 4 times to the total number of species (expressed as a percentage) are depicted in Figure 23 (data in Appendix Table A4).

Dominant taxa - The most abundant taxa in the Buccaneer Field study area were the Polychaeta and the Amphipoda (the percent composition of all taxa are listed in Appendix Table A5). These two groups accounted for at least 85% of all organisms at most stations; the prominent exceptions were station 6, which had a large archiannelid (*Polygordius appendiculatus*) population in July, station 64, which had a massive set of young bivalves in January, and station 109, which had numerous cephalochordates (*Branchistoma caribaeum*) in the assemblage. The remaining taxa were present in small percentages.

The polychaetes comprised about 65-75% of the population at most stations in the study area (Fig. 24). The percentage was less than 60% at one location, a group of three stations on transect A in the eastern end of the study area.

The amphipods, which were dominated by *Ampelisca abdita*, comprised 10-20% of the total population at most stations (Fig. 25). At stations 35 and 36, on the northeastern side of Platform B, amphipods comprised less than 10% of the total population; transect E in general tended to have smaller percentages of amphipods than the other transects. The amphipod percentage was > 35% at the group of three stations on transect A where polychaete percentages were low.

The tendency for the populations of the 26 numerically dominant species to increase, decrease, remain unchanged, or to vacillate with decreasing distance from the platforms is shown in Table 3. Slightly more than half the species decreased in abundance while only four tended to increase. The areal distributions of two of the species that decreased in abundance are shown in Figures 26 and 27. The distribution of *Ampelisca abdita* is of particular interest because ampeliscid amphipods have been used as indicators of hydrocarbon pollution.

Pteropod shells in the sediments - When the benthic samples were being processed, it was apparent that large numbers of empty, but intact, pteropod shells were present in the vicinity of the oil field structures. Pteropods are planktonic snails that swim by flapping a pair of lateral extensions of the foot (called "wings") and are not components of the benthic fauna. The distribution of the total number of shells (4 collections) is shown in Figure 28. The largest numbers were collected at stations 9 and 26, which were adjacent to well jackets. Stations 4 and 88, which were near, but not close to, well jackets had higher numbers of shells in the sediments than more remote stations.

Large numbers of shells were also collected in proximity to Platforms A and B. At station 3, adjacent to the north side of Platform A, the July samples contained large numbers of *Creseis* pteropods that were either alive or very recently killed at the time of collection. The flesh was still in the shells and showed no signs of decay. A few intact specimens were collected at station 1 also.

Numerical Analysis

Numerical analysis was first performed on combined data from the four collections, then on each quarterly collection. At least two analyses were run on each data set, the second analysis incorporating additional, but less frequently occurring, species.

The site group dendrogram and the areal extent of the site groups obtained by analysis of the combined data are shown in Figures 29 and 30 respectively. These groups are based on 67 species and are virtually identical with the analysis performed with 83 species (not shown). Four site groups were produced. Site group I consisted of the majority of the stations in the study area, all with a high degree of ecological similarity. Site group II was a cluster of five stations with reduced populations, most of which were located in the vicinity of exposed clay toward the eastern end of the study area (station 104, while it had reduced populations, was sampled only three times, reducing the combined population even more). Site group III consisted of stations in proximity to Platforms A and B. Site group IV consisted of two stations, 64 and 109, which were unrelated to any of the other station clusters and relatively unrelated to each other.

The combined data analysis yielded six species groups (Fig. 31). Species group I was a large group of uniquitous species, all of which occurred at nearly every station. Species group II consisted of 9 species that occurred infrequently in site groups III and IV. The species in group III occurred infrequently in site group II. Species group IV consisted a single organism, *Balanoglossus* sp., that was absent from site groups II, III, and IV. The animals in species group V occurred more frequently and in greater numbers in site group III than in other site groups. The last species group, VI, consisted of a species of young bivalve that was collected primarily at station 64. The relative frequency of occurrence of the species groups in each site group is summarized in Table 4. Site group II (clay bottoms) was characterized by infrequent occurrence and low populations of the species in groups III, IV and V. Site group III (around the platforms) was characterized by infrequent occurrence of species in groups II and IV, and by high frequency and relatively large populations of species in group V.

Analyses of the quarterly collections (not shown) produced essentially similar results. Several stations in proximity to the platforms formed the nucleus of a distinct site group that was characterized by the presence of some species, the absence of others, and reduced numbers of individuals compared with the main site group.

Meiobenthic Populations

The meiofaunal data are not as extensive as the macrofaunal data; only the first of three replicate samples collected at each station was analyzed. About 81,000 meiofaunal specimens (raw numbers) were counted during the study. The extrapolation of raw meiofaunal data to numbers of individuals/m^2 results in very large, and perhaps meaningless, numbers. Therefore, unless otherwise stated, it will be understood that the discussion of meiofaunal data will be in terms of average numbers of individuals/cm^2.

The diversity of meiofaunal populations was not determined because of the considerable time necessary to identify nematodes. A list of identified meiofaunal organisms is presented in Appendix Table A6.

Seasonal Trends

The average number of individuals per station collected in each quarter is compared with the sediment temperature trend in Figure 32. The smallest population occurred in October-November, followed by a population increase through April. This trend did not correspond with changes in sediment temperature and presumably was related to another abiotic or biological factor.

Areal Distribution

The average quarterly meiobenthic population at each station is shown in Figure 33. Most stations had in excess of 110 individuals, but in three areas populations were less than 110 individuals. These areas included the 15 m stations around Platform B, a crescent-shaped area west, south and east of Platform A, and two stations south of Platform A on transect B. These data, while suggesting that the meiofaunal populations were depressed around the platforms, are erratic. On the eastern leg of transect A, the population at station 7 (adjacent to Platform A) was twice as large as at station 8 (50 m from the platform). On the southern leg of transect B, the populations at stations 2 and 91 (adjacent to and 100 m from Platform A respectively) had low populations while the intermediate station (1) had large populations. I attribute these erratic population fluctuations, at least in part, to the fact that only four meiofaunal data points were available per station, vs. 12 for the macrofauna.

Dominant Taxa

The dominant taxa among the meiofauna were the Nematoda, the Foraminifera and the Harpacticoida (the percent composition of each group is presented in Appendix Table A7). There was no obvious pattern in the distribution of the nematode percentage (Fig. 34). Foraminifera comprised 1-6% of the population at most stations except to the north and east of Platform A where the percentage was > 10% (Fig. 35). The percentage of harpacticoid copepods varied considerably throughout the field, ranging from 8 to 26%. A region north, west and south of Platform A had depressed populations of less than 7%, except the anomalous station 6 which had 27% (Fig. 36).

Macrobenthic vs. Meiobenthic Populations

Figure 37 compares seasonal trends of macro- and meiofaunal populations. The trends do not correspond; the lowest meiofaunal population occurred in October-November, a quarter before the lowest macrofaunal population. The macrofaunal population appeared to be directly related to the sediment temperature changes. The meiofaunal population was apparently related to some unknown factor, perhaps predation.

When the pilot study data were analyzed, the macro- and meiofaunal population sizes appeared to be inverse (Harper, Scrudato and Giam, 1976). However, during the present study, the coefficients of correlation between macro- and meiofaunal populations were very low for each quarter and for all four quarters combined (Table 5). Thus it appears that there was no correlation between the sizes of these populations during this study.

Discussion

The data indicate that the macrobenthic populations around Platforms A and B were different from those in most of the study area. The near-platform populations were depressed, had a relatively high species turn-over rate and had few species that were more frequently found there than in the remainder of the field. The meiobenthic populations may also have been depressed around the platforms, but the fewer data and the large populations close to Platform A followed by smaller populations away from the platform make the data difficult to interpret.

There are three main probable causes for the relatively poor populations around the platforms, viz: 1) a toxic substance from the platforms was killing organisms relatively quickly after they settled, causing a low population and a high turn-over rate; 2) the harder substrate in the vicinity of the platforms was unsuitable for habitation for many of the benthic invertebrates; 3) the fish and larger invertebrates that congregated around the platforms were preying heavily on the benthic fauna.

The third reason is unlikely because stations in the vicinity of wells should have had a similar reduction in population. The harder substrate near the platforms may account for part of the decrease in population, because the stations located in the vicinity of the exposed clay toward the eastern end of the study area also had reduced populations. In contrast, the soft muddy sand observed in the vicinity of the well jackets contained larger populations. However, the population depression extended outward from the immediate vicinity of Platform A and onto softer bottoms. Therefore, hard bottoms were not the definitive cause of the population depressions.

The release of toxic subtances from the platform may also account for some of the decrease in population. The metal junk on the bottom around the platforms, or the metal of the platforms themselves, could be releasing trace metals into the water. Anderson, Schwarzer and Clark (1978) detected enriched concentrations of Pb, Zn and Sr near Platforms A and B. In contrast, the bottoms investigated around the well jackets were relatively clear of metal debris.

There is also a possibility that substances in the bleedwater being discharged from the platforms effected a population decrease. While dilution and diffusion is probably rapid most of the time, there may be hydrographic conditions, i.e., slack current, in which the high salinity brine flows to the bottom as a density current.

Also of interest are the areas of enriched macrofaunal populations that occurred at stations 1000-2000 m north and east of Platforms A and B. The occurrences of depressed populations in the vicinity of the platforms and enriched areas at some distance from the platforms are similar to the results of Mackin's (1971) study of the effects of bleedwater discharge on the biota of Trinity Bay, Texas. In Mackin's study, the bottom close to the bleedwater outlet was saturated with oil and nearly abiotic. At distances of about 15 to 100 m from the platform, the populations were depressed compared with control stations, but no trace of oil could be detected in the sediments by sight or smell. The zone of inhibition was followed by a zone of enrichment, beyond which was an area of "control" populations intermediate in size between those of the zones of inhibition and enrichment. The members of Mackin's research team (of which I was a member) speculated that in the zone of enrichment, the level of toxic materials in the bleedwater (probably aromatic hydrocarbons) was reduced and that the remaining hydrocarbons were being degraded by bacterial populations, and that these bacterial populations were being fed upon by the benthic organisms. It is possible that hydrocarbons are being carried to the bottom in Buccaneer Field and the enriched zones correspond to areas of high bacterial activity. This possibility should be investigated in future work.

It is also obvious that something associated with the structures caused an accumulation of pteropod shells. There are numerous possible causes of this accumulation. Any substance that would cause mortality or inhibition of the neuromotor activity associated with swimming would cause the animal to sink, dragged down by the weight of its shell. Possible toxic or inhibitory substances in the water column include the bleedwater (which contains not only oil and high brine concentrations, but bacteriocides as well), leakage of hydrocarbons from the structures, and toxic antifouling or anticorrosion coatings on the structural members of platforms and well jackets. The platforms and well jackets are also heavily used by sportsfishermen whose boats discharge exhaust gases, fuel and oil into the water.

Predation by rig-associated fish is a second highly probable cause of pteropod shell accumulation around structures. The pteropods, *Clio* and *Cavolina* were found in the stomachs of several species of fish caught near structures, viz: jewfish (*Epinephelus itajara*), spade fish (*Chaetodipterus faber*), gray triggerfish (*Balistes capriscus*), blue runner (*Caranx crysos*) and red snapper (*Lutjanus campechanus*), according to Fotheringham (1978). Ingestion of the living pteropods and subsequent defecation of the shells by fish that are closely associated with the structures could account for much of the accumulation of shells in the vicinity of the structures, assuming that the shells are not crushed when eaten and pass intact through the fishes' digestive systems. This does not, however, account for the numerous "live" pteropods in the July benthic sample at station 3. It is unlikely that the "live" pteropods were being collected from the water column because the Ekman grabs have vent flaps to allow free passage through the water column. Shelled pteropods migrate vertically through the water column, rising to the surface at twilight and descending about midnight (Hyman, 1967). It is possible that swarms of pteropods being carried into the field by currents, contacted the bottom during the descent phase of migration and remained there, or became disoriented, or perhaps came in contact with toxic substances in the sediments. Unless the pteropods are highly sensitive to the toxic substances, the latter is somewhat unlikely because large populations of benthic organisms were found adjacent to the well jacket at station 26 where large accumulations of pteropod shells occurred.

The accumulation of pteropod shells is an interesting phenomenon and should be studied further. Bioassays should be run on pteropods to determine if they are extremely sensitive to any of the materials being introduced into the environment by production operations.

RECOMMENDATIONS

The results of the one year study showed that the macrobenthic populations were depressed near Platforms A and B, and that apparent zones of enrichment occurred 1000-2000 m distant from the platforms. The data also indicate that populations in the vicinity of the platforms are unstable and have a rapid turn-over rate. I recommend that the area between the platform and the enriched area be investigated more fully. This investigation should be completely coordinated with geological and chemical sampling so that the interrelationships between macrobenthic populations and bacterial populations, sediment characteristics, hydrocarbon concentrations, total organic concentrations and trace metal concentrations can be determined. Sampling should be concentrated in one area, probably near Platform A. A transect should be established with stations more closely spaced than the spacing used on this study, viz: 0, 10, 25, 50, 100, 300, 500, 1000, 1500 and 2000 m from the platform. The transect should run to the northeast or east from Platform A. Samples should be collected at least eight times per year.

Laboratory toxicity studies should be conducted with pteropods collected in the study area to determine if they are sensitive to any materials being released in the field.

It would also be interesting to place fine mesh cages on the bottom in the vicinity of the platform and remote from the platform to protect the macrobenthic organisms from predation. This would permit an evaluation of the role of predation in reducing the populations in the vicinity of the platforms.

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Neal Baxter, National Marine Fisheries Service, Galveston, obtained the 1976-77 National Ocean Survey temperature data.

Robert Case, computernick, was responsible for computerized data storage and retrieval. The numerical analysis program was written by Robert Smith, University of Southern California. William Clayton, Provost of Moody College, provided one hour of computer time.

Vicki Tyson typed the manuscript. John Clary prepared the final draft of all figures.

LITERATURE CITED

Anderson, J. B., R. R. Schwarzer and H. C. Clark. 1978. Geologic investigation of the Buccaneer Oil/Gas Field. In: Environmental assessment of an active oilfield in the northwestern Gulf of Mexico. Report to the Environmental Protection Agency by the National Marine Fisheries Service, Gaveston, Texas.

Behrens, E. W. 1978. Total organics and C^{13}/C^{12} ratio in sediments from an active oil field and an unaltered area. In: Environmental assessment of an active oilfield in the northwestern Gulf of Mexico. Report to the Environmental Protection Agency by the National Marine Fisheries Service, Galveston, Texas.

Bureau of Land Management. 1977. Environmental studies South Texas outer continental shelf, 1975: An atlas and integrated summary. H. L. Berryhill (ed.). 303 pp.

Clifford, H. T. and W. Stephenson. 1976. An introduction to numerical classification. Academic Press, New York.

Fisher, W. L., J. H. McGowen, L. F. Brown, Jr. and C.G. Groat. 1972. Environmental atlas of the Texas coastal zone - Galveston-Houston area. Bureau of Economic Geology, Univ. Texas, Austin, Texas. 91 pp.

Fotheringham, N. 1978. Effects of offshore oil field structures on their biotic environment. Part I: Benthos and plankton. In: Environmental assessment of an active oil field in the northwestern Gulf of Mexico. Report to the Environmental Protection Agency by the National Marine Fisheries Service, Galveston, Texas.

Harper, D. E., Jr., R. J. Scrudato and C. S. Giam. 1976. A preliminary environmental assessment of the Buccaneer Oil/Gas Field. Final report to National Marine Fisheries Service on negotiated contract 03-6-042-35110.

Holland, J. S. 1976. Benthos project. In: Environmental studies, South Texas outer continental shelf, 1975, biology and chemistry. Report to the Bureau of Land Management from the University of Texas, Texas A&M University and Rice University on contract 08550-CT5-17.

Hyman, L. 1967. The Invertebrates. Vol. VI. Mollusca I. McGraw-Hill Book Co., New York. 792 pp.

Mackin, J. G. 1971. A study of the effects of oil field brine effluents on biotic communities in Texas estuaries. Texas A&M Research Foundation Project 735 Report.

Mackin, J. G. and S. H. Hopkins. 1961. Studies on oyster mortality in relation to natural environments and to oil fields in Louisiana. Publs. Inst. Mar. Sci. Univ. Texas 7: 1-131.

Martin, J. A. 1978. Hydrography of the Buccaneer Oil Field and adjacent waters. In: Environmental assessment of an active oil field in the northwestern Gulf of Mexico. Report to the Environmental Protection Agency by the National Marine Fisheries Service, Galveston, Texas.

Middleditch, B. S., B. Basile and E. S. Chang. 1978. Determination of hydrocarbon levels and pathways in the major components of the marine ecosystem in an active oilfield and an unaltered area. In: Environmental assessment of an active oilfield in the northwestern Gulf of Mexico. Report to the Environmental Protection Agency by the National Marine Fisheries Service, Galveston, Texas.

Smith, R. W. Numerical analysis of ecological survey data. Ph.D. Thesis. Biology Dept., University of Southrn California.

Temple, R. F., D. L. Harrington and J. A. Martin. 1977. Monthly temperature and salinity measurements of continental shelf waters of the northwestern Gulf of Mexico, 1963-1965. NOAA Tech. Rept. SSRF-207.

APPENDIX

Table 1. Distance and Direction of Stations in Buccaneer Field and Vicinity from Either Platform A or B.

Transect A

Station	Distance (m)	Direction
	From Platform A	
14	4000	263°
10	3000	263°
94	2000	263°
95	1000	263°
4	100	263°
5	50	263°
6	< 15	263°
7	< 15	83°
8	50	83°
9	100	83°
96	1000	83°
11	2000	83°
97	3000	83°
12	4500	83°
13	6000	83°
70	8000	83°
98	11000	83°
71	7250	71°

Transect B

Station	Distance (m)	Direction
	From Platform A	
109	8000	353°
108	4000	353°
21	3000	353°
107	2000	353°
106	1000	353°
18	100	353°
17	50	353°
3	< 15	353°
2	< 15	187°
1	50	187°
91	100	187°
90	500	187°
89	1000	187°
88	2000	187°
*45	2500	187°

*< 15 m from Platform B

Transect C

Station	Distance (m)	Direction
	From Platform A	
7	15	34°
26	1250	34°
105	2000	34°
64	4000	34°

Transect D

Station	Distance (m)	Direction
	From Platform A	
7	15	109°
93	2000	109°
40	3000	109°
62	5000	109°
92	7500	109°

Transect E

Station	Distance (m)	Direction
	From Platform B	
32	1500	244°
86	900	
34	15	244°
35	15	64°
36	50	64°
87	1000	64°
39	2000	64°
40	3000	64°

Table 2. List of the 26 species with >5000 total individuals/m^2 ranked in order of numerical dominance. Also listed are the average number of individuals/m^2 at each station in each quarter. *maximum populations,- minimum populations

Species	July	Oct.-Nov.	Jan.-Feb.	April	Total
Lumbrineris tenuis	708.7-	1093.9*	979.3	859.4	171174
Ampelisca abdita	1322.1*	358.0-	359.0	974.6	143028
Aricidea fragilis	981.2*	658.9	519.8-	767.5	137232
Mediomastus californiensis	219.8-	679.8*	279.3	253.8	66972
Cossura delta	304.6	302.4	270.2-	350.6*	57724
Magelona sp.	430.3*	255.7-	266.4	264.3	57026
Tharyx sp.	597.0*	211.4	148.7-	152.9	51659
Nereis sp.	88.0-	194.7*	132.6	94.7	23912
Aglaophamus verrilli	94.8-	121.6*	111.3	106.0	20385
Tanaidacea, spiny rostrum	186.0*	44.1	41.2-	68.8	15863
Tellina versicolor	76.2-	152.1*	82.1	78.0	18188
Armandia maculata	15.2-	130.9*	95.6	49.0	13662
Prionospio pinnata	177.6*	51.6	25.7	24.0-	12925
Photis sp.	60.9	31.3-	46.5	108.7*	11689
Cerebratulus lacteus	88.1*	71.5	37.6-	50.7	11579
Ceratocephale sp.	35.3-	60.0	41.4	86.1*	10501
Aspidosiphon speciosus	50.7	44.7-	47.2	67.5*	9895
Melinna maculata	33.5	26.8	66.7*	25.2-	7182
Oxyurostylis salinoi	38.7	21.9	8.2-	68.3*	6460
Anthuridae A	35.7*	31.0	35.5	25.8-	6010
Abra aequalis	105.3*	12.9	4.0	1.5-	5698
Sthenelais boa	55.2*	31.2	15.1-	19.5	5637
Nemertea (yellow band)	45.5*	37.0	15.8-	22.4	5624
Glycera americana	23.3	7.5-	26.9	54.3*	5315
Clymenella zonalis	58.0*	30.8	14.0	9.7-	5224
Giant Sperm	35.6*	17.6-	23.5	31.4	5085
#spp with largest pop.	13	6	1	6	
#spp with smallest pop.	7	6	8	5	

Table 3. List of the 26 numerically dominant species and their tendency to increase or decrease in numbers or remain unchanged with decreasing distance from the platforms.

Species	Decrease	Irregular or No Change	Increase
Lumbrineris tenuis		X	
Ampelisca abdita	X		
Arcidea fragilis	X		
Mediomastus californiensis		X	
Cossura delta	X		
Magelona sp.	X		
Tharyx sp.		X	
Nereis sp.			X
Aglaophamus verrilli	X		
Tanaidacea, spiny rostrum		X	
Tellina versicolor	X		
Armandia maculata			X
Prionospio pinnata		X	
Photis sp.	X		
Cerebratulus lacteus			X
Ceratocephale sp.	X		
Aspidosiphon speciosus	X		
Melinna maculata	X		
Oxyurostylis salinoi			X
Anthuridae A		X	
Abra aequalis		X	
Sthenelais boa	X		
Nemertea, yellow band	X		
Glycera americana	X		
Clymenella zonalis	X		
Giant sperm		X	
Total	14	8	4

Table 4. Relative abundance of species groups I-VI at site groups I-IV, based on combined macrobenthic data from the Buccaneer Field study.

	Site Groups			
Species Groups	I	II	III	IV
I	+++	+++	+++	+++
II	++	++	+	+
III	++	+	++	+++
IV	++	0	0	0
V	++	+	+++	+
VI	0	+	0	+

Table 5. Coefficients of correlation, macrobenthic vs. meiobenthic populations, for each quarter and for the four quarters combined

Quarter	Coefficient of Correlation
July	-0.130
October-November	0.154
January-February	0.004
April	0.519
Combined	0.273

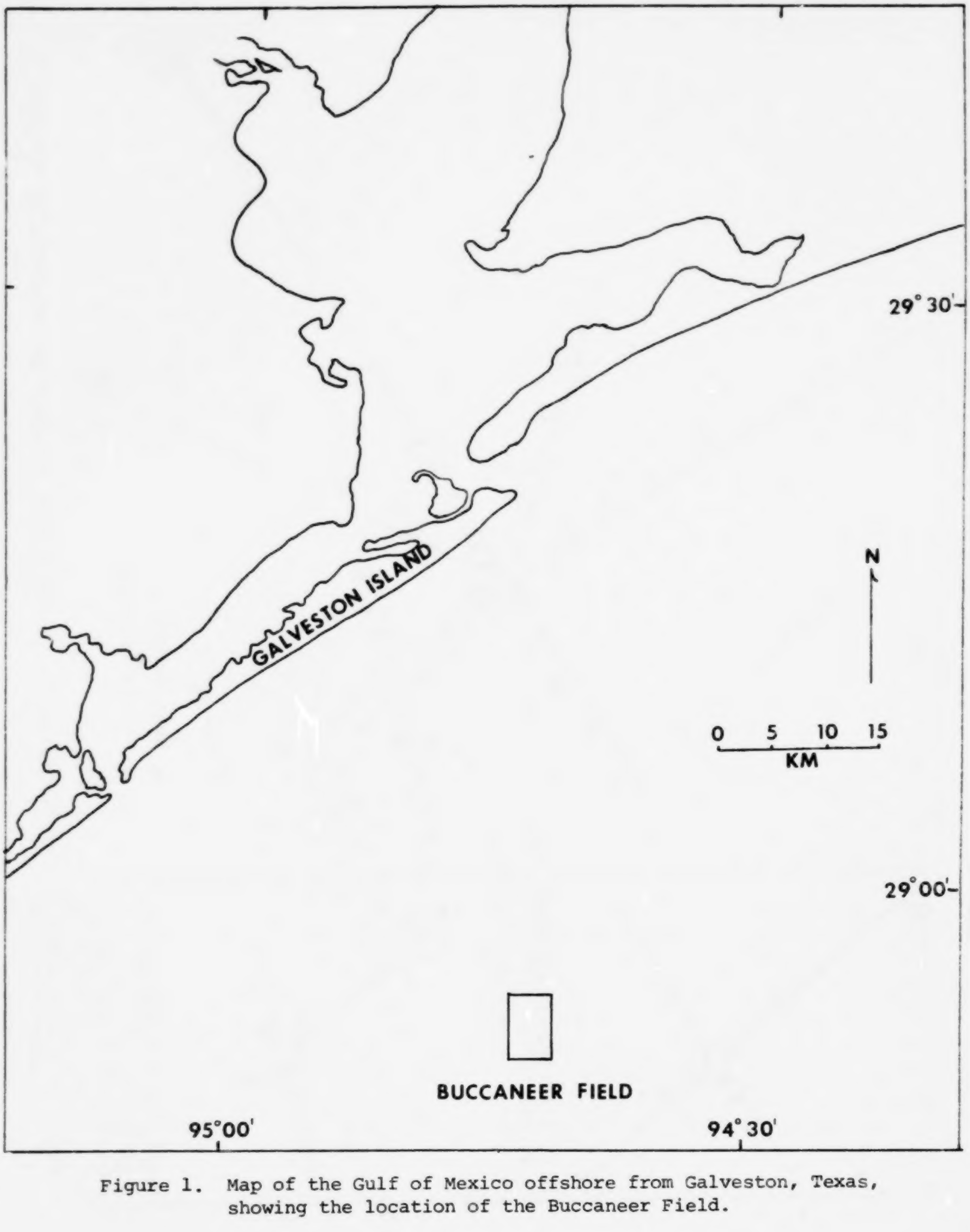
GALVESTON ISLAND
N
0 5 10 15
KM
29° 30'
29° 00'
BUCCANEER FIELD
95°00'
94° 30'

Figure 1. Map of the Gulf of Mexico offshore from Galveston, Texas, showing the location of the Buccaneer Field.

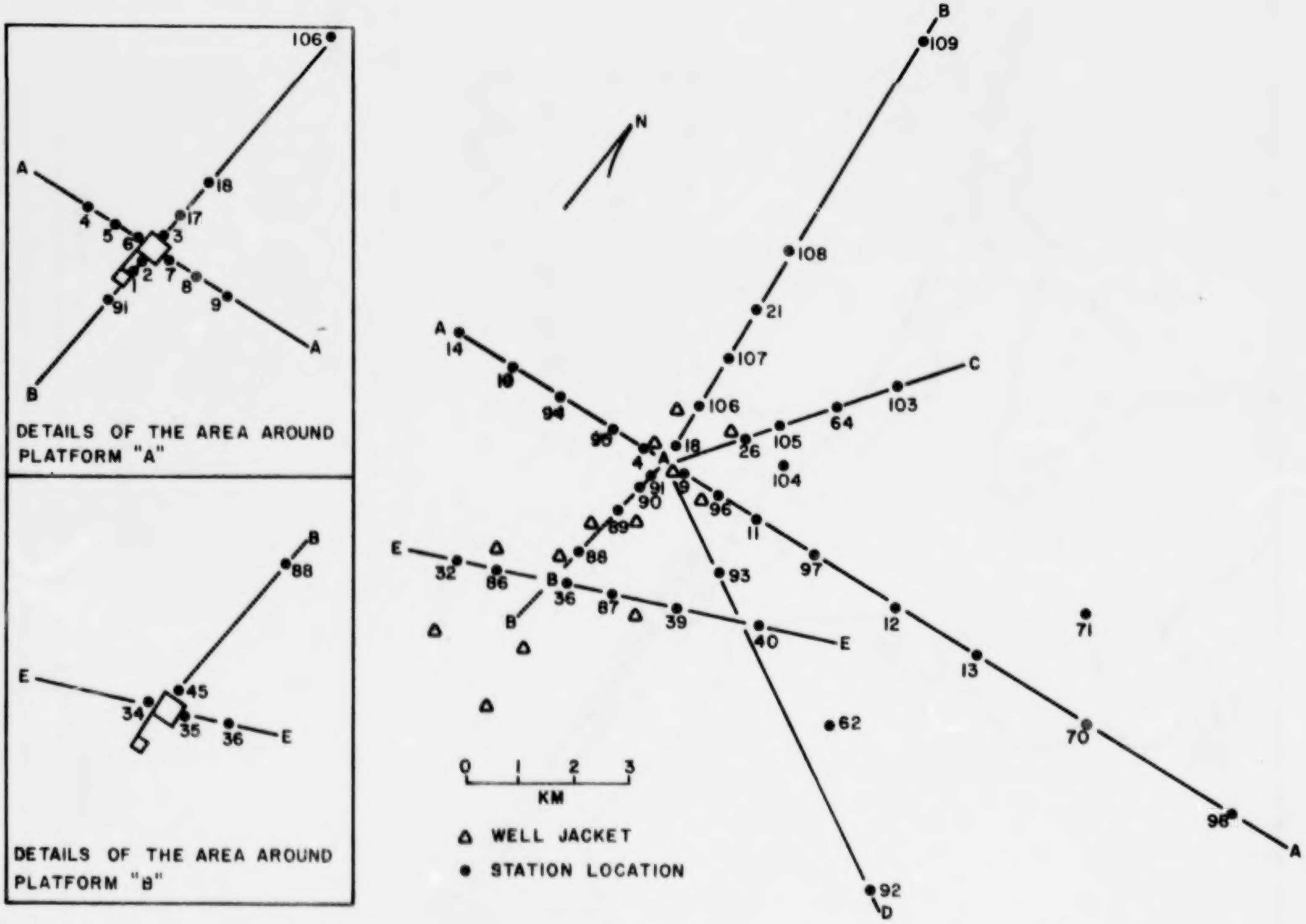
106
A
18
17
4
5
6
3
2
7
8
1
9
91
A
B
DETAILS OF THE AREA AROUND
PLATFORM "A"
B
88
E
45
34
35
36
E
DETAILS OF THE AREA AROUND
PLATFORM "B"
N
B
109
108
21
107
106
C
103
64
105
26
104
A
14
10
94
95
4
18
A
9
91
90
96
89
11
88
97
E
32
86
B
36
87
39
93
12
40
E
B
71
13
62
70
0
1
2
3
KM
98
A
△ WELL JACKET
● STATION LOCATION
92
D

Figure 2. Map of the Buccaneer Field and vicinity showing the transects and locations of stations sampled during the study.

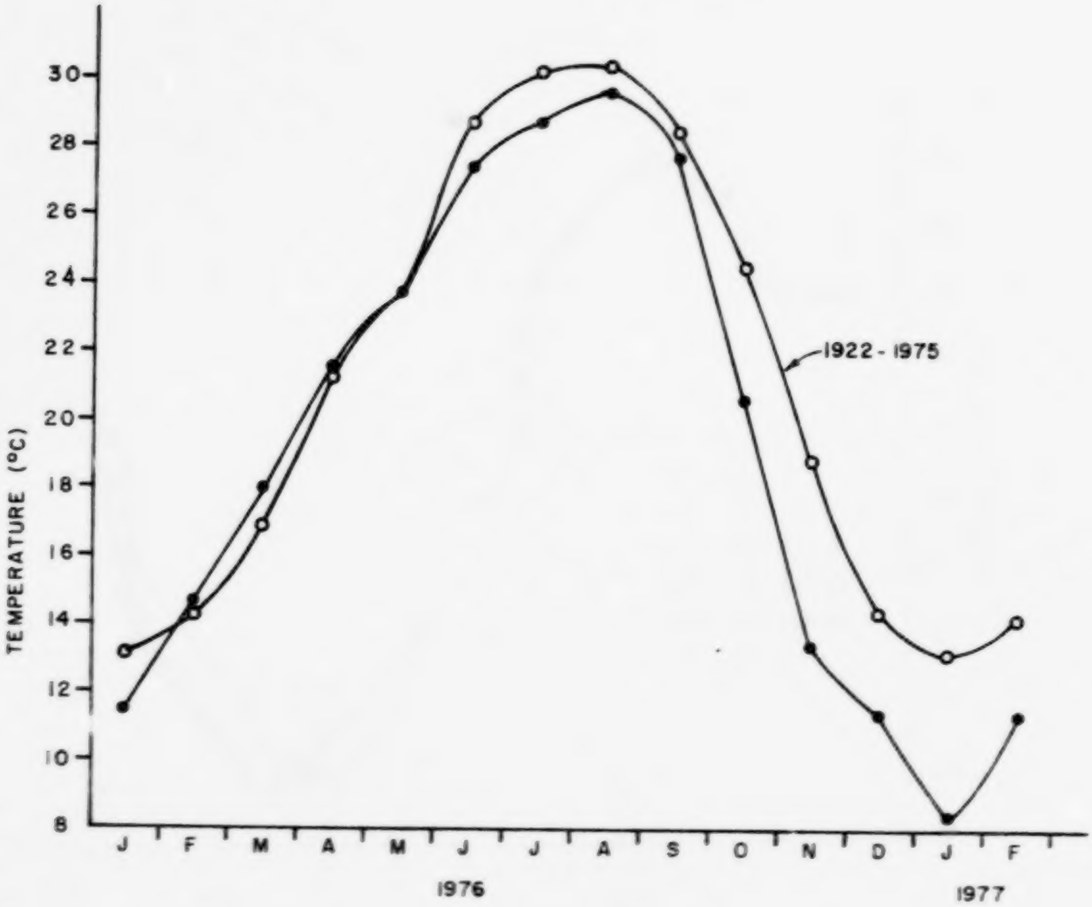

Figure 3. Comparison of the water temperature trends in the Galveston Channel, January 1976 through February 1977, with the average trend, 1922 through 1975.

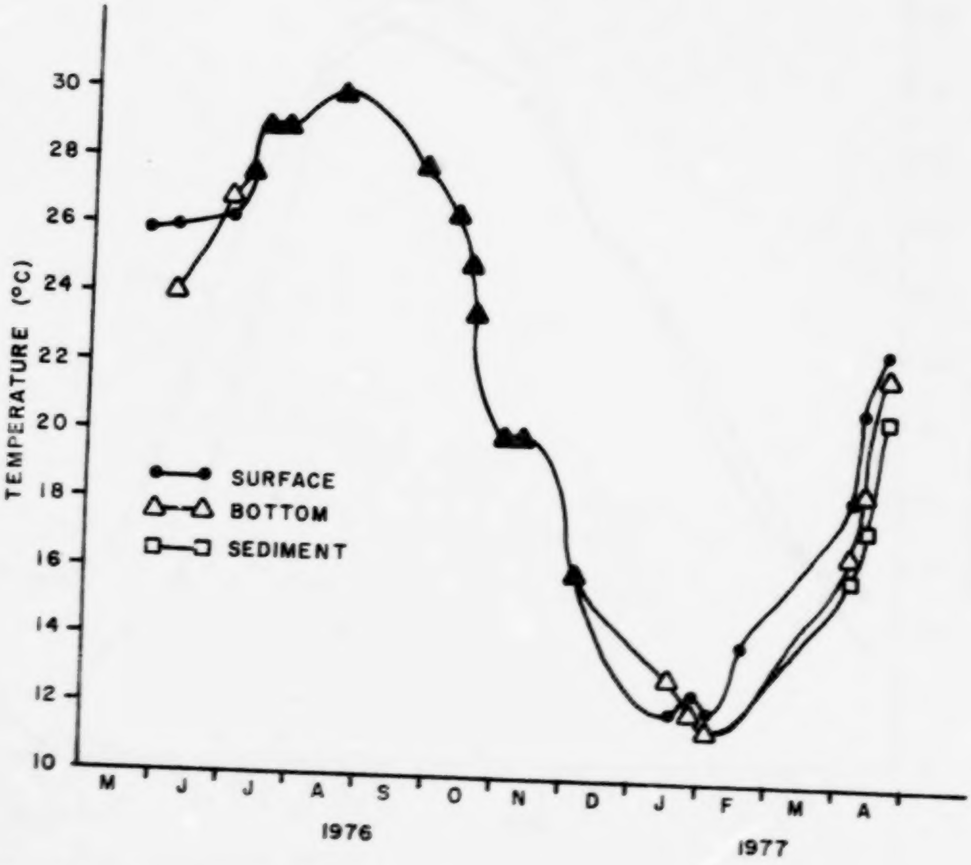

Figure 4. Temperature trends of the surface and bottom waters and the sediments in the Buccaneer Field study area, May 1976 through April 1977.

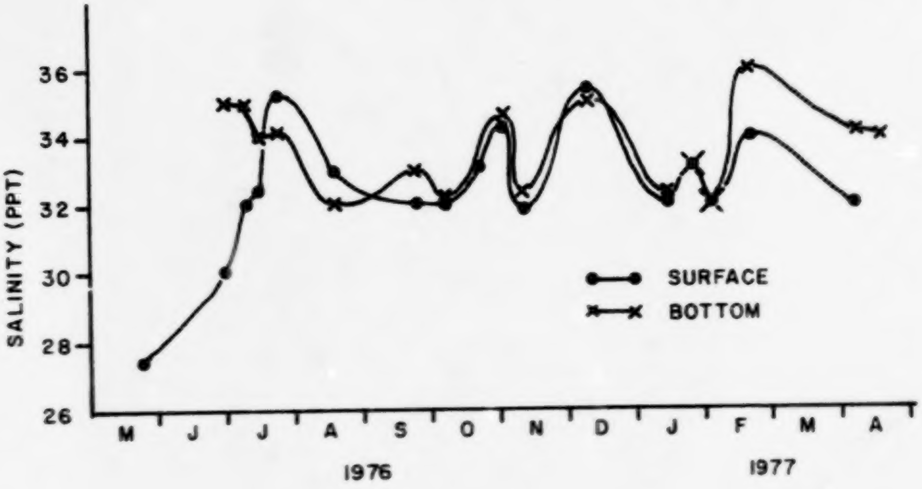

Figure 5. Salinity trends of the surface and bottom waters in the Buccaneer Field study area, May 1976 through April 1977.

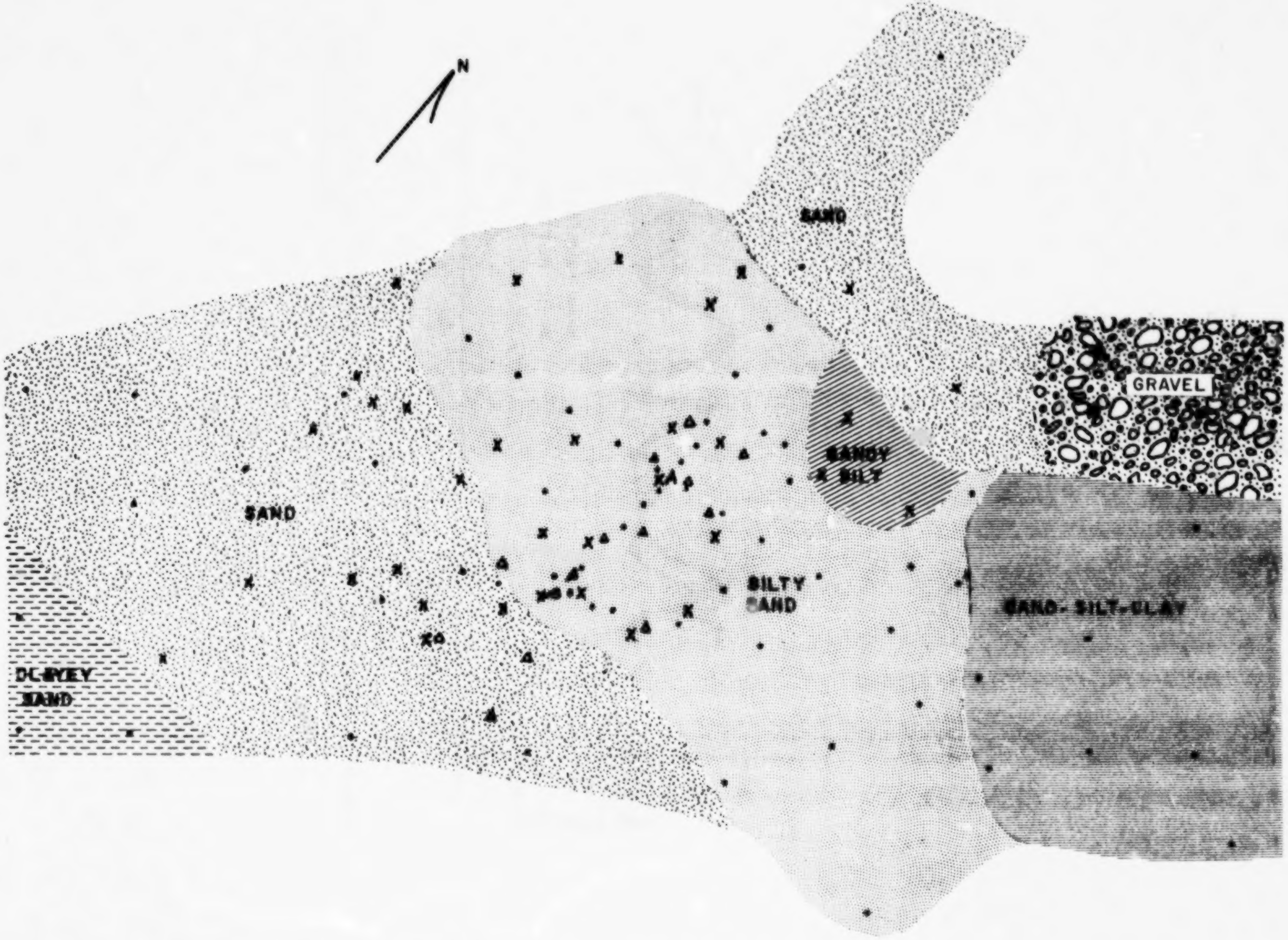
N
SAND
SAND
GRAVEL
SANDY SILT
SILTY SAND
SAND-SILT-CLAY
CLAYEY SAND

Figure 6. Distribution of sediments in the Buccaneer Field study area. x - pilot study station; • - experimental study station

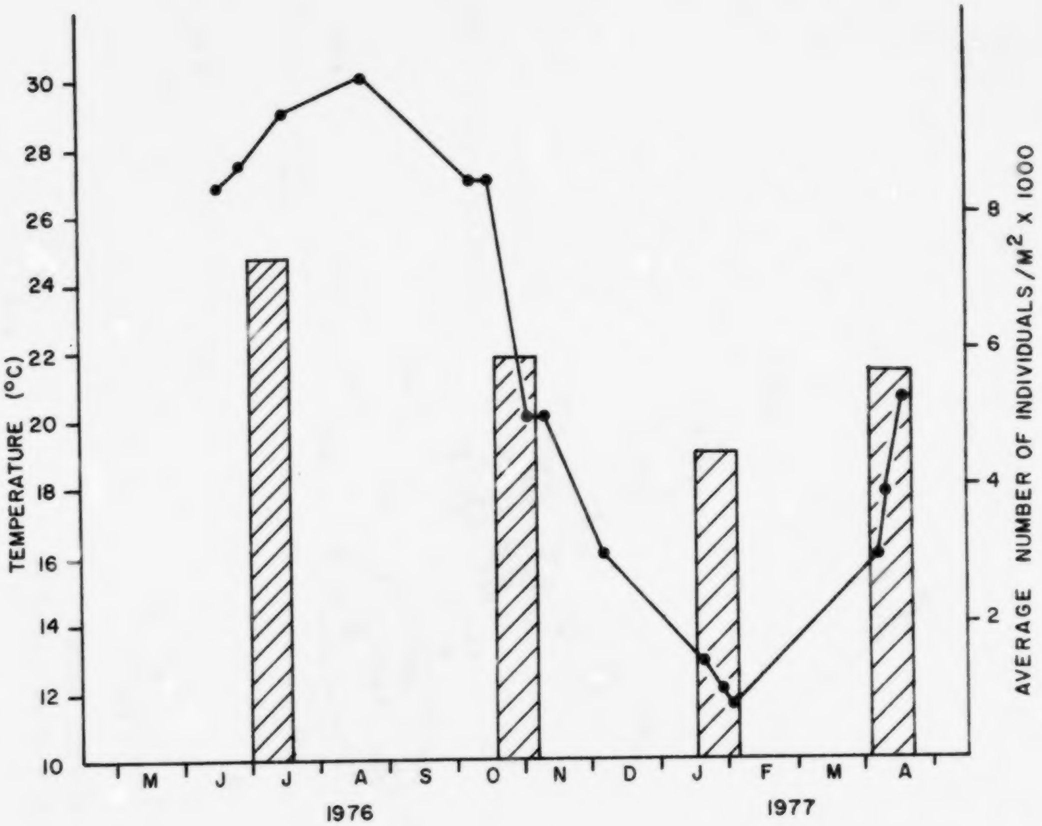

Figure 7. Comparison of the macrobenthic population and sediment temperature trends in the Buccaneer Field study area.

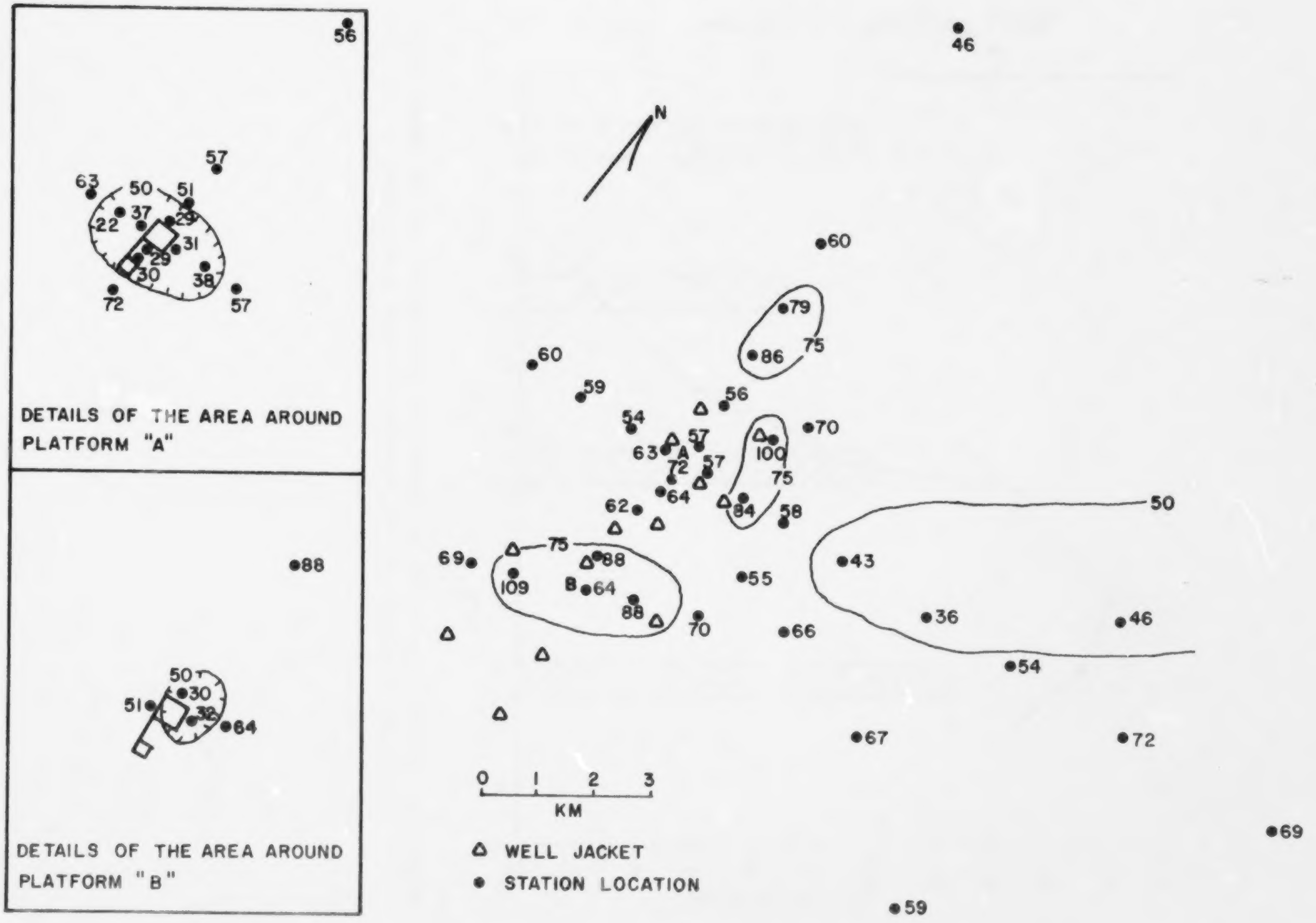
DETAILS OF THE AREA AROUND PLATFORM "A"
56
57
63
50
51
37
22
29
31
29
30
38
72
57
DETAILS OF THE AREA AROUND PLATFORM "B"
88
50
30
51
32
64
N
46
60
79
86
75
60
59
56
54
70
57
63
A
72
57
100
75
64
62
84
58
50
69
75
88
109
B
64
88
70
55
43
36
46
66
54
67
72
0
1
2
3
KM
69
WELL JACKET
STATION LOCATION
59

Figure 8. Map of the Buccaneer Field study area showing the areal distribution of the macrobenthic populations (average number of individuals/m^2 per quarter x 100). Suggested isodemes are superimposed.

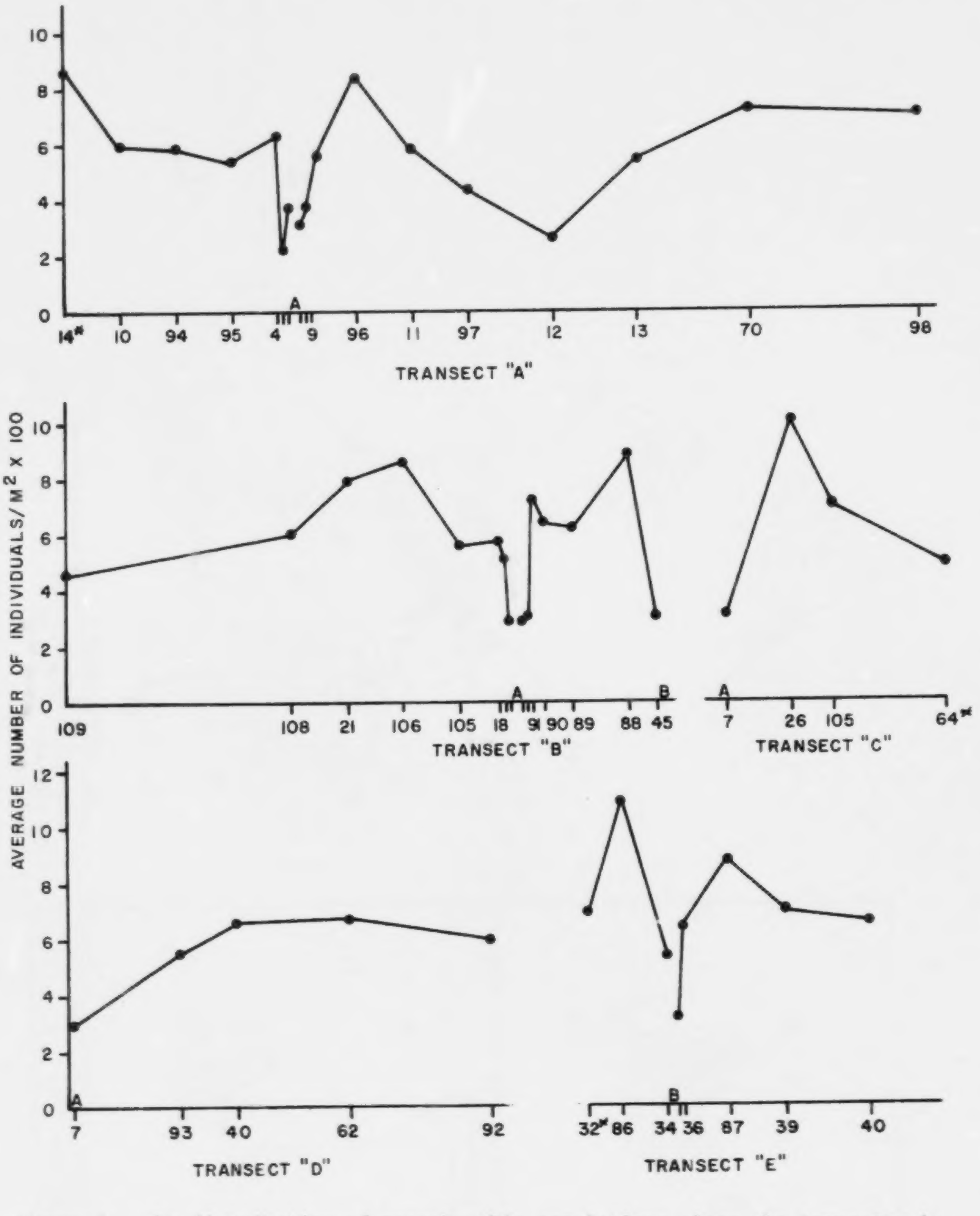

Figure 9. The distribution of macrobenthic populations along the transects in the Buccaneer Field study area. Stations not numbered (left to right) are: Transect A - 5, 6, 7, 8; Transect B - 17, 3, 2, 1; Transect E - 35. * - average of only three collections.

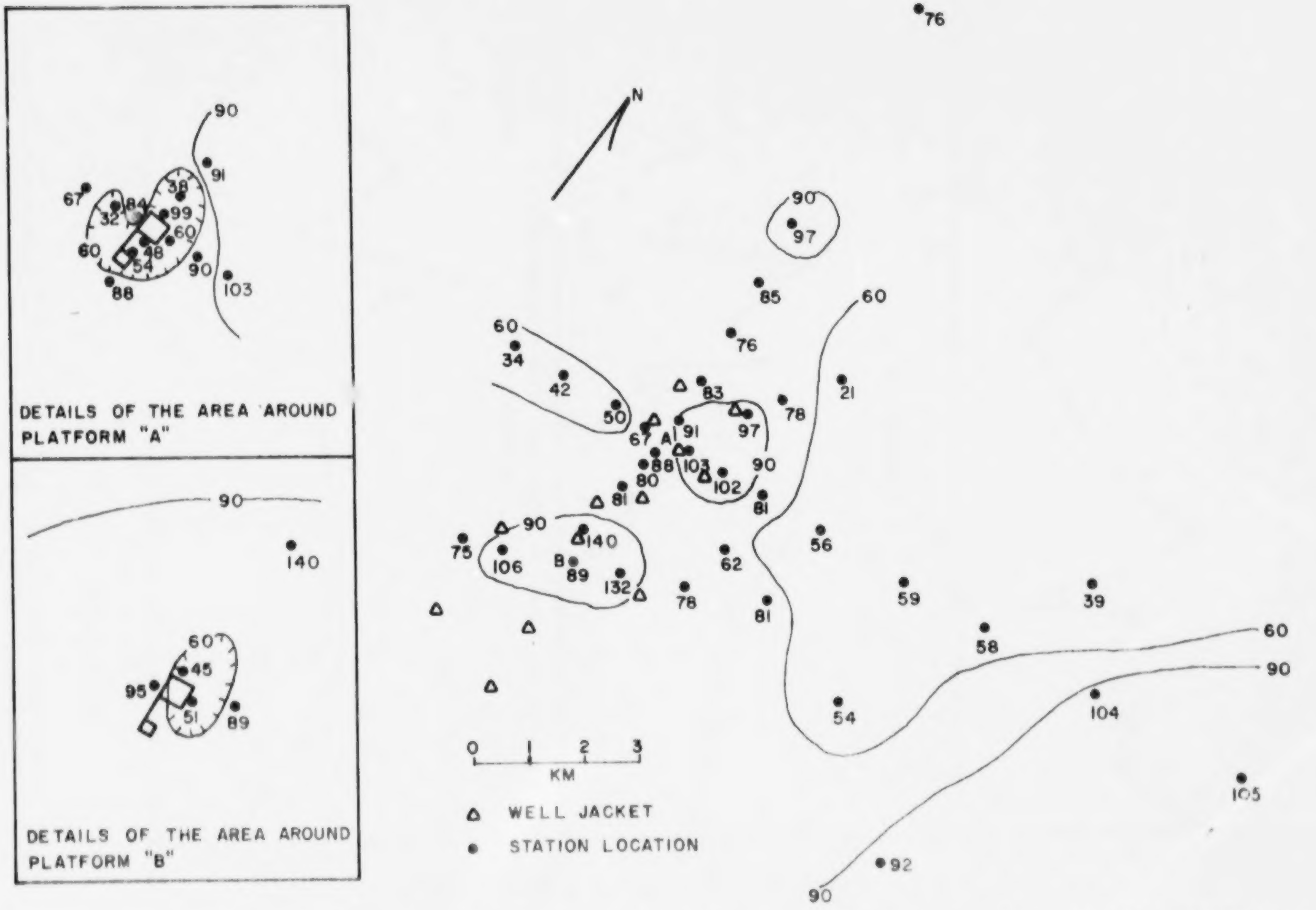
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
0
1
2
3
KM
Δ WELL JACKET
● STATION LOCATION
A
B
60
90
76
97
85
34
42
50
83
91
103
102
81
67
88
80
78
21
56
59
39
58
104
105
54
92
75
106
140
89
132
62
38
99
32
84
48
54
88
45
51
95

Figure 10. Map of the Buccaneer Field study area showing the areal distribution of macrobenthic populations during the July 1976 quarter. Suggested isodemes are superimposed. All numbers are x 100.

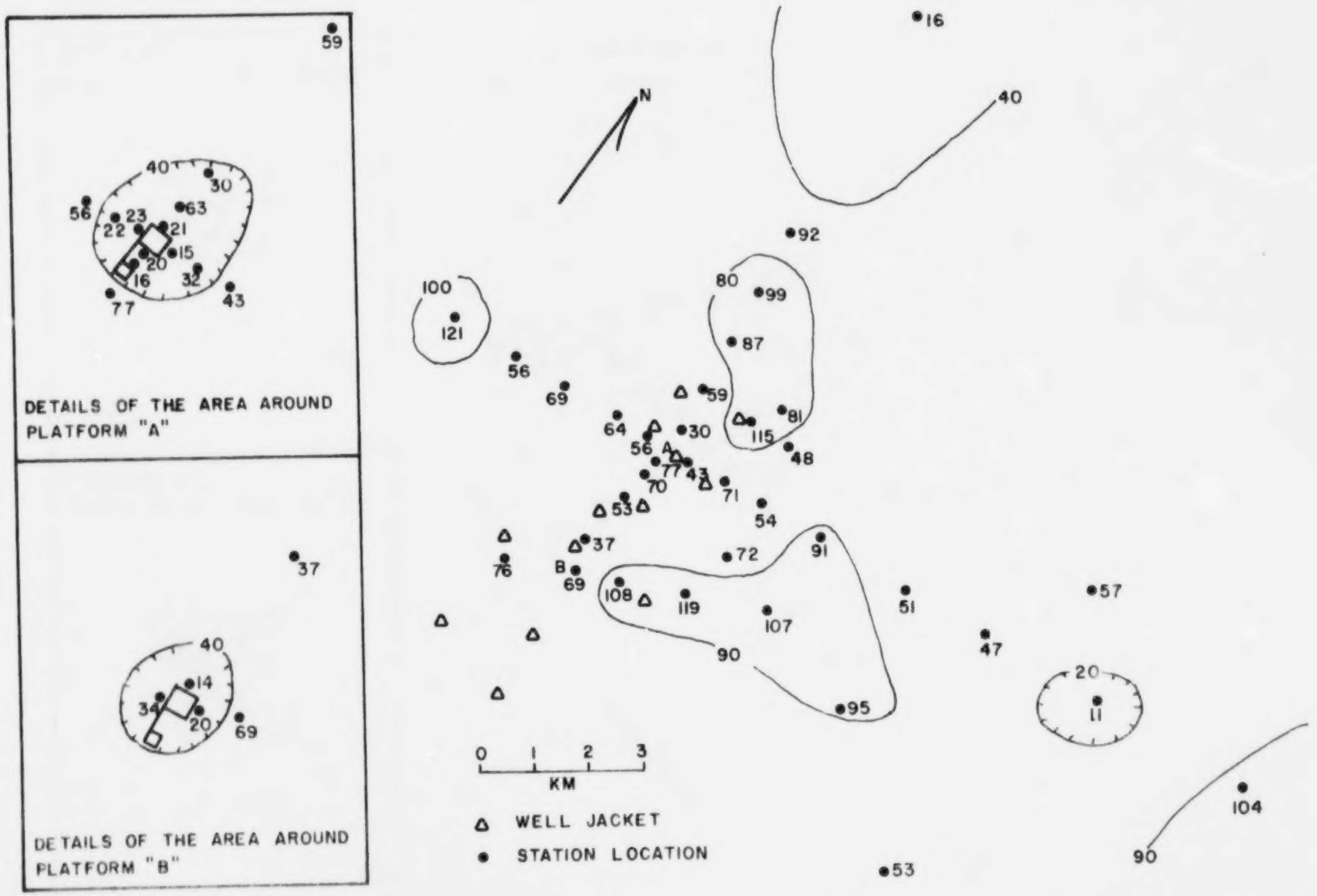
DETAILS OF THE AREA AROUND PLATFORM "A"
59
40
30
56
23
63
22
21
15
20
16
32
77
43
DETAILS OF THE AREA AROUND PLATFORM "B"
37
40
14
34
20
69
N
16
40
92
100
121
80
99
87
56
69
59
81
64
30
115
48
56
A
77
43
70
71
53
54
37
91
72
B
76
69
108
119
107
51
57
90
47
20
11
95
0
1
2
3
KM
WELL JACKET
STATION LOCATION
104
90
53

Figure 11. Map of the Buccaneer Field study area showing the areal distribution of macrobenthic populations during the October-November 1976 quarter. Suggested isodemes are superimposed. All numbers are x 100.

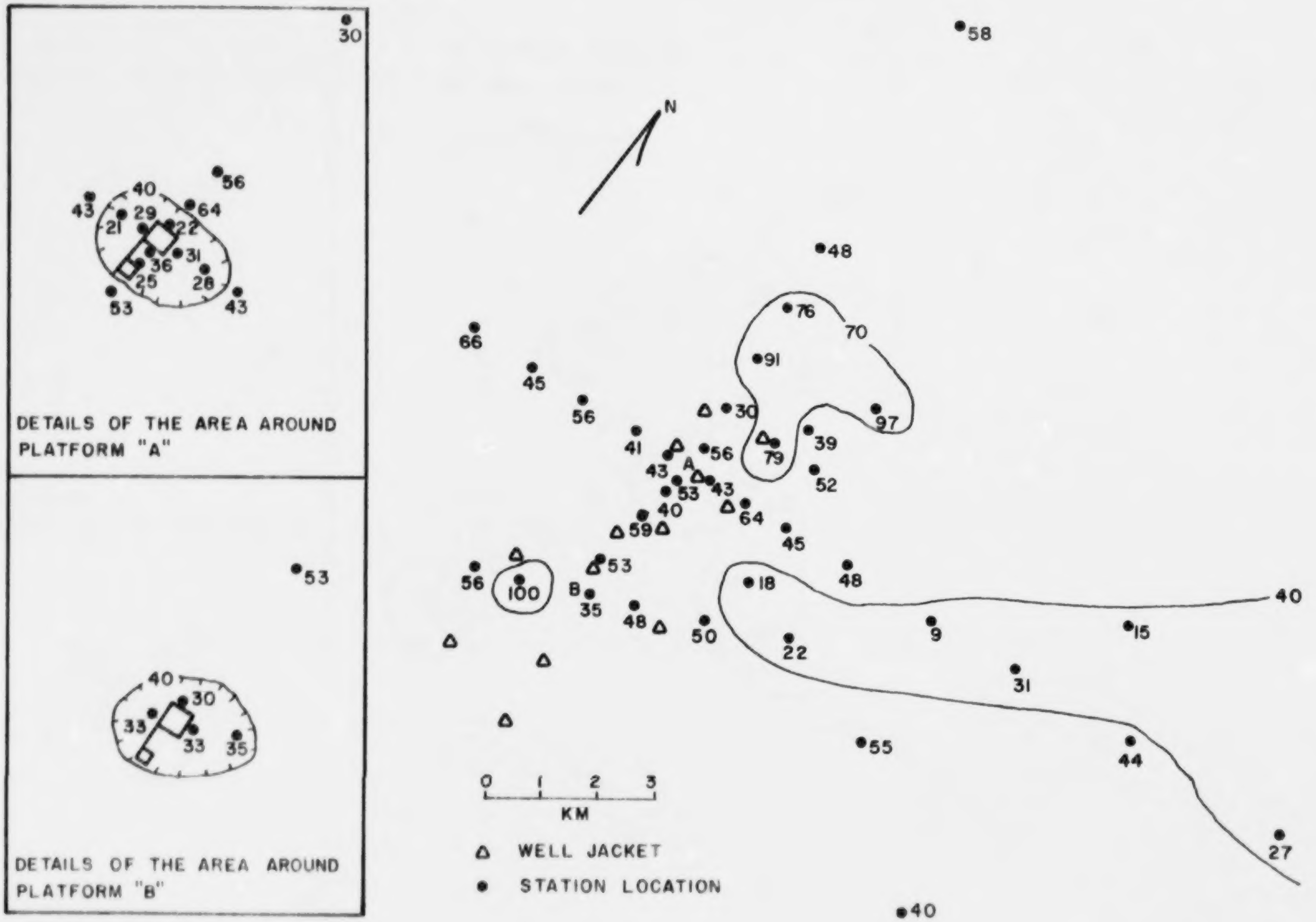
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
A
B
70
40
0 1 2 3
KM
WELL JACKET
STATION LOCATION

Figure 12. Map of the Buccaneer Field study areas showing the areal distribution of macrobenthic populations during the January-February 1977 quarter. Suggested isodemes are superimposed. All numbers are x 100.

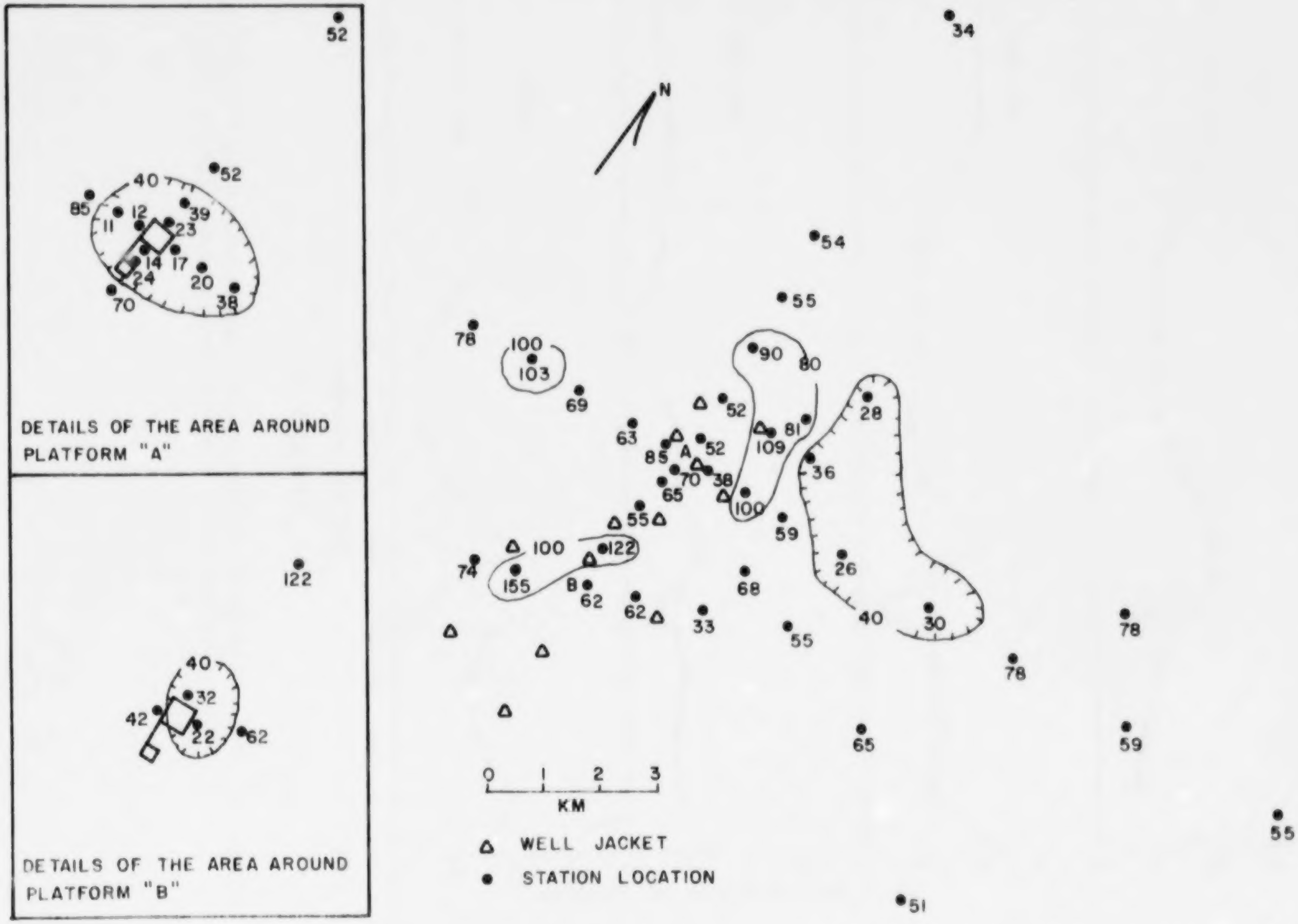
DETAILS OF THE AREA AROUND PLATFORM "A"
52
85
40
11
12
39
23
14
17
24
20
70
38
52
DETAILS OF THE AREA AROUND PLATFORM "B"
122
40
32
42
22
62
N
34
54
55
78
100
103
69
90
80
52
63
85
A
52
109
81
28
36
70
38
65
55
100
59
74
100
122
155
B
62
62
33
68
26
55
40
30
78
78
65
59
55
51
0
1
2
3
KM
△ WELL JACKET
● STATION LOCATION

Figure 13. Map of the Buccaneer Field study area showing the areal distribution of macrobenthic populations during the April 1977 quarter. Suggested isodemes are superimposed. All numbers are x 100.

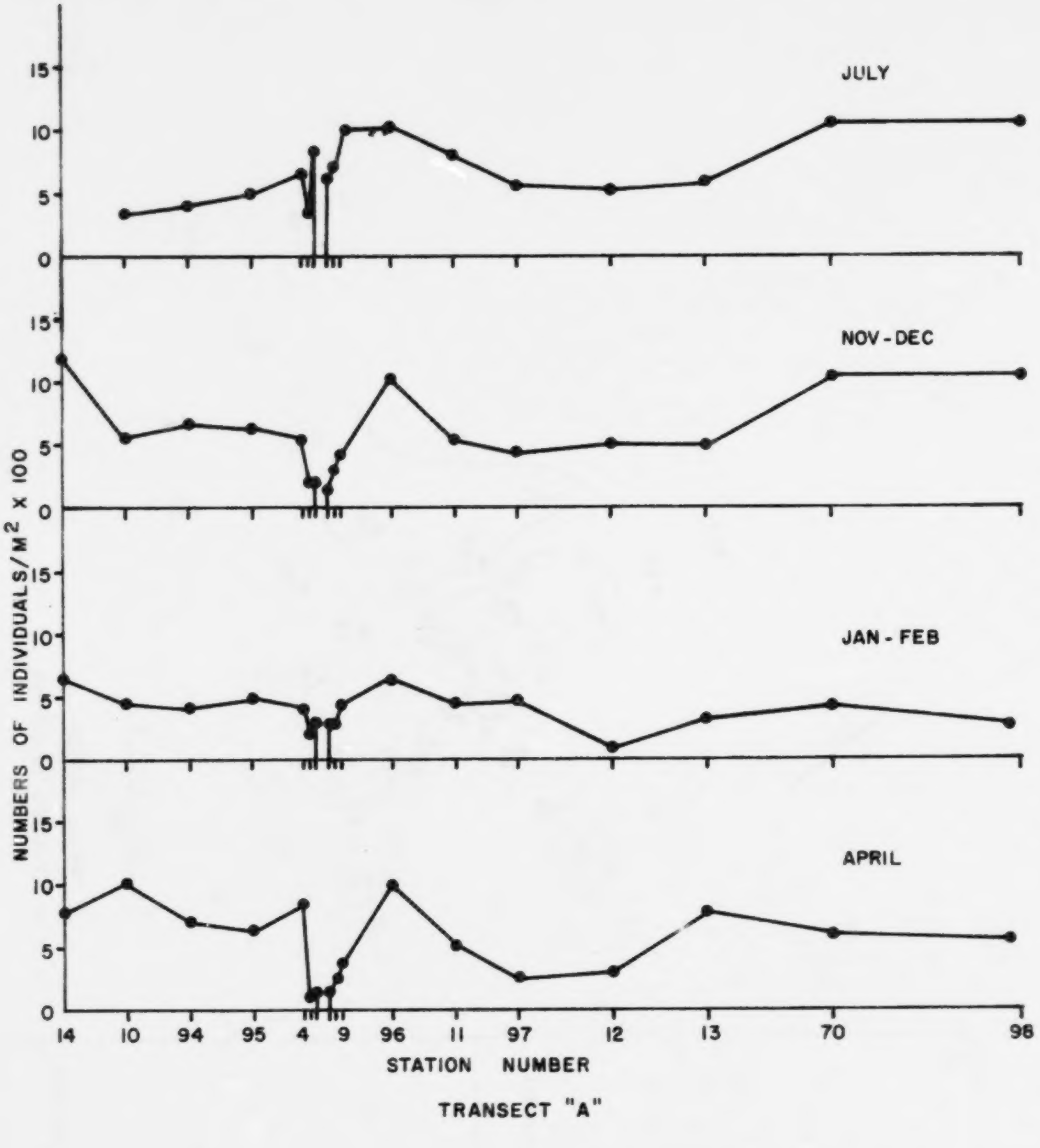

Figure 14. The distribution of macrobenthic populations along Transect A in all four quarters. Stations not numbered (left to right) are: 5, 6, 7, 8.

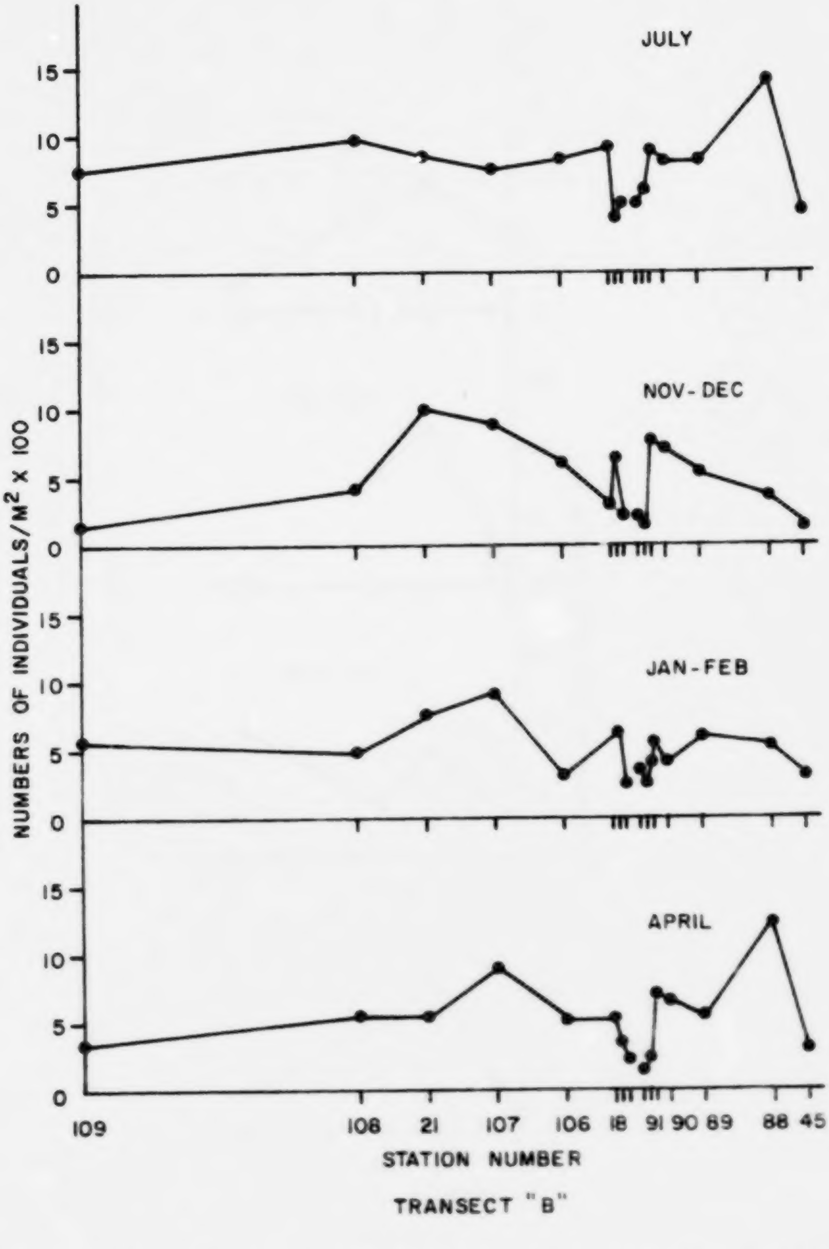

Figure 15. The distribution of macrobenthic populations along Transect B during all four quarters. Stations not numbered (left to right) are: 17, 3, 2, 1.

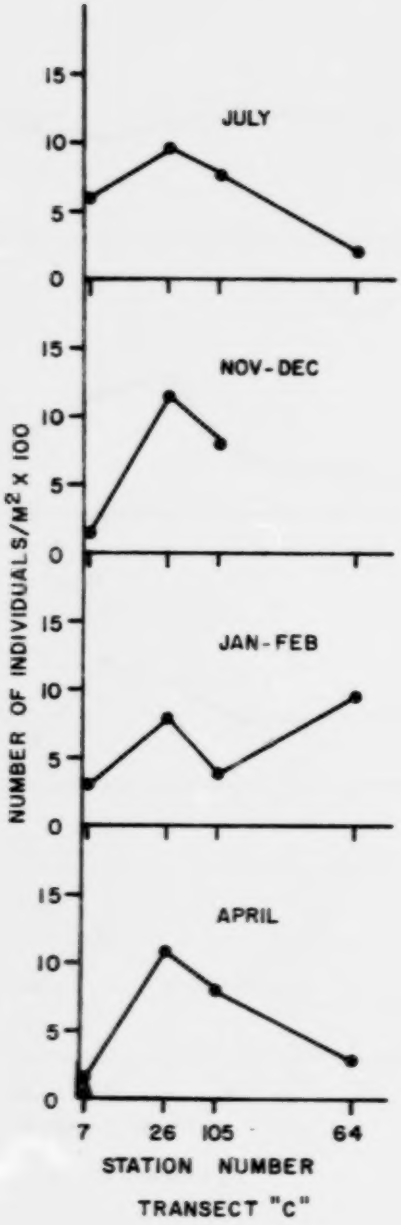

Figure 16. The distribution of macrobenthic populations along Transect C in all four quarters.

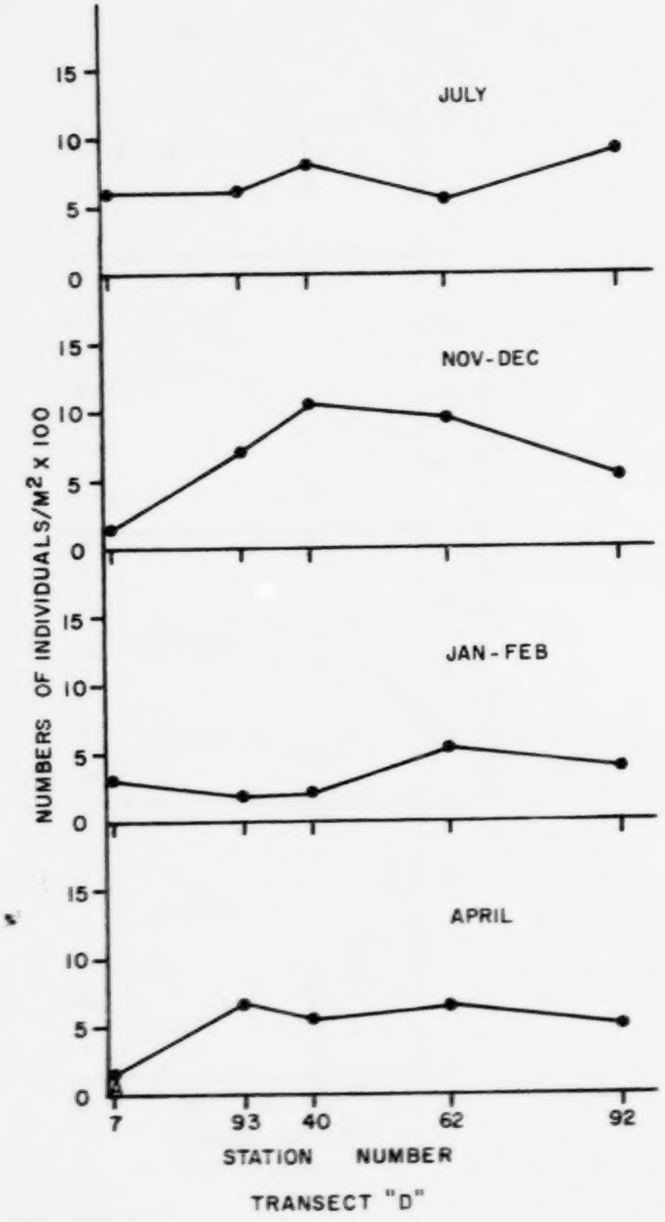

Figure 17. The distribution of macrobenthic populations along Transect D during all four quarters.

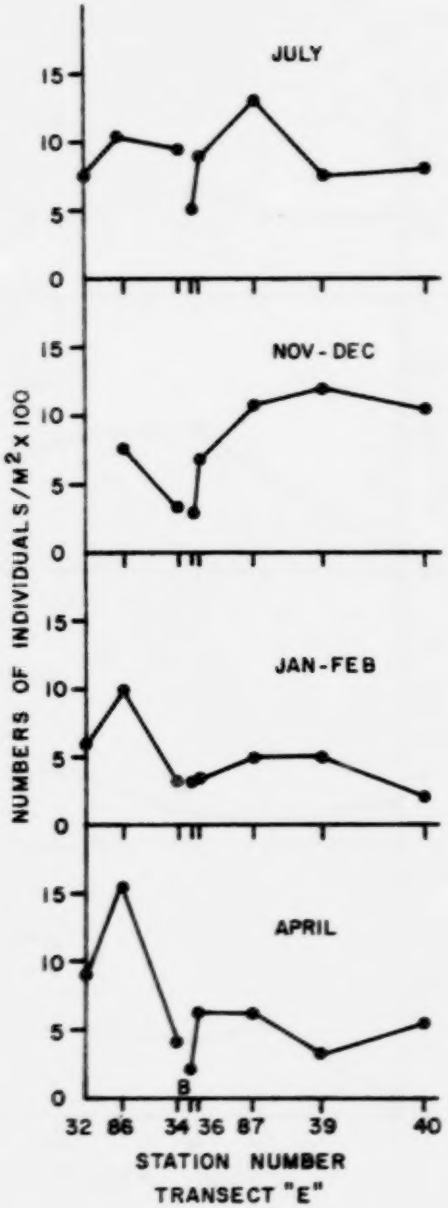

Figure 18. The distribution of macrobenthic populations along Transect E during all four quarters. The station not numbered is 35.

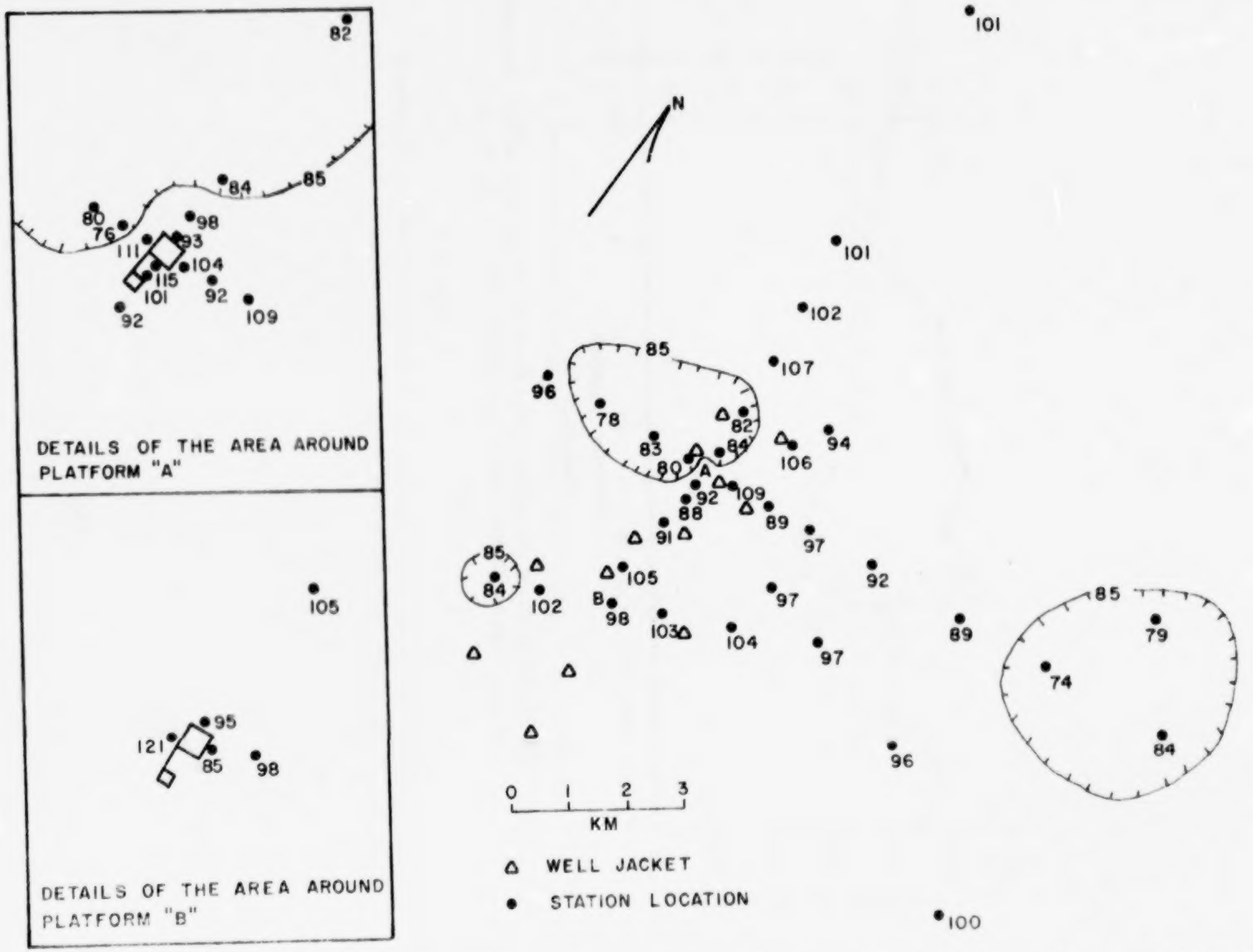
DETAILS OF THE AREA AROUND PLATFORM "A"
82
84
85
80
76
98
111
93
104
115
101
92
92
109
DETAILS OF THE AREA AROUND PLATFORM "B"
105
95
121
85
98
N
101
101
102
107
85
96
78
82
83
84
80
A
106
94
92
109
88
89
91
97
85
84
105
102
B
98
92
97
103
104
89
97
85
79
74
84
96
0
1
2
3
KM
WELL JACKET
STATION LOCATION
100

Figure 19. Map of the Buccaneer Field study area showing the areal distribution of the macrobenthic total diversity during the study. Suggested isopleths are superimposed.

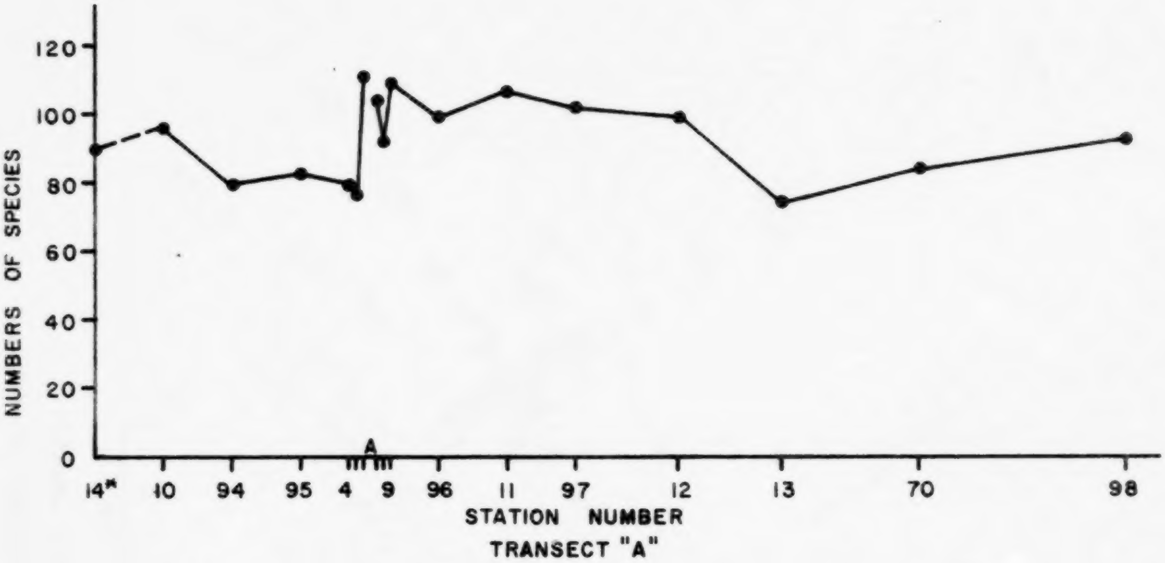

Figure 20. The distribution of macrobenthic total diversity along Transect A. Stations not numbered (left to right) are: 5, 6, 7, 8.

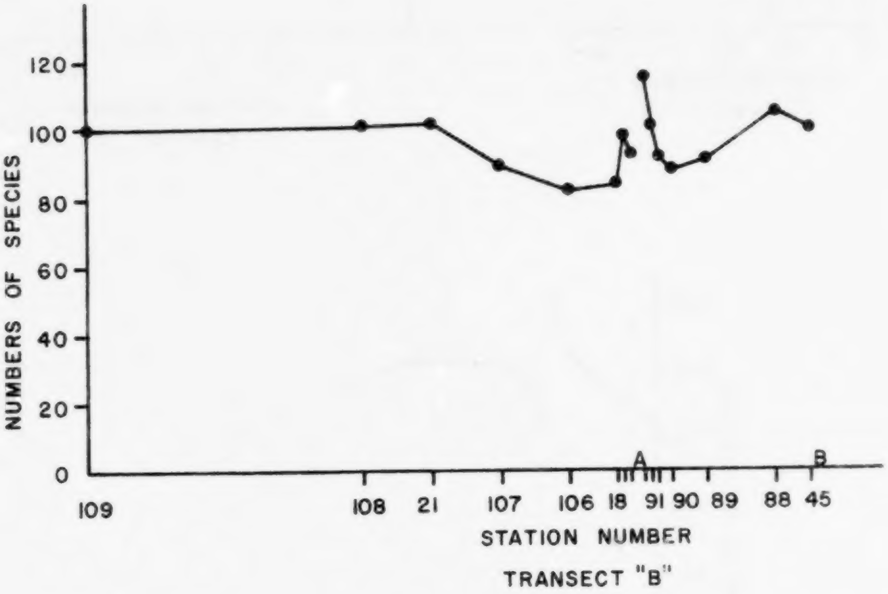

Figure 21. The distribution of macrobenthic total diversity along Transect B. STations not numbered (left to right) are: 17, 3, 2, 1.

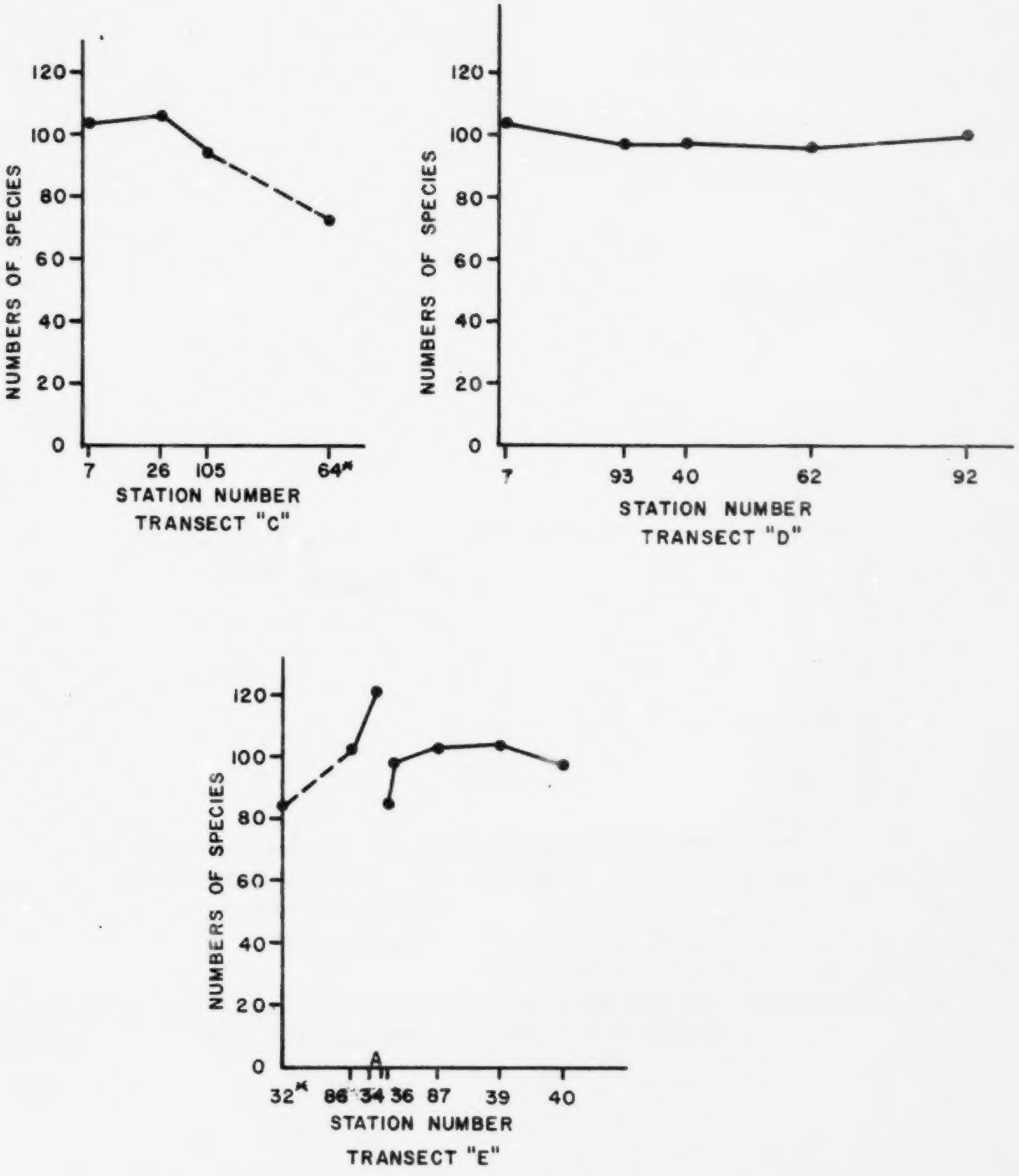

Figure 22. The distribution of macrobenthic total diversity along Transects C, D and E. * - only three collections. Unnumbered station in Transect E is 35.

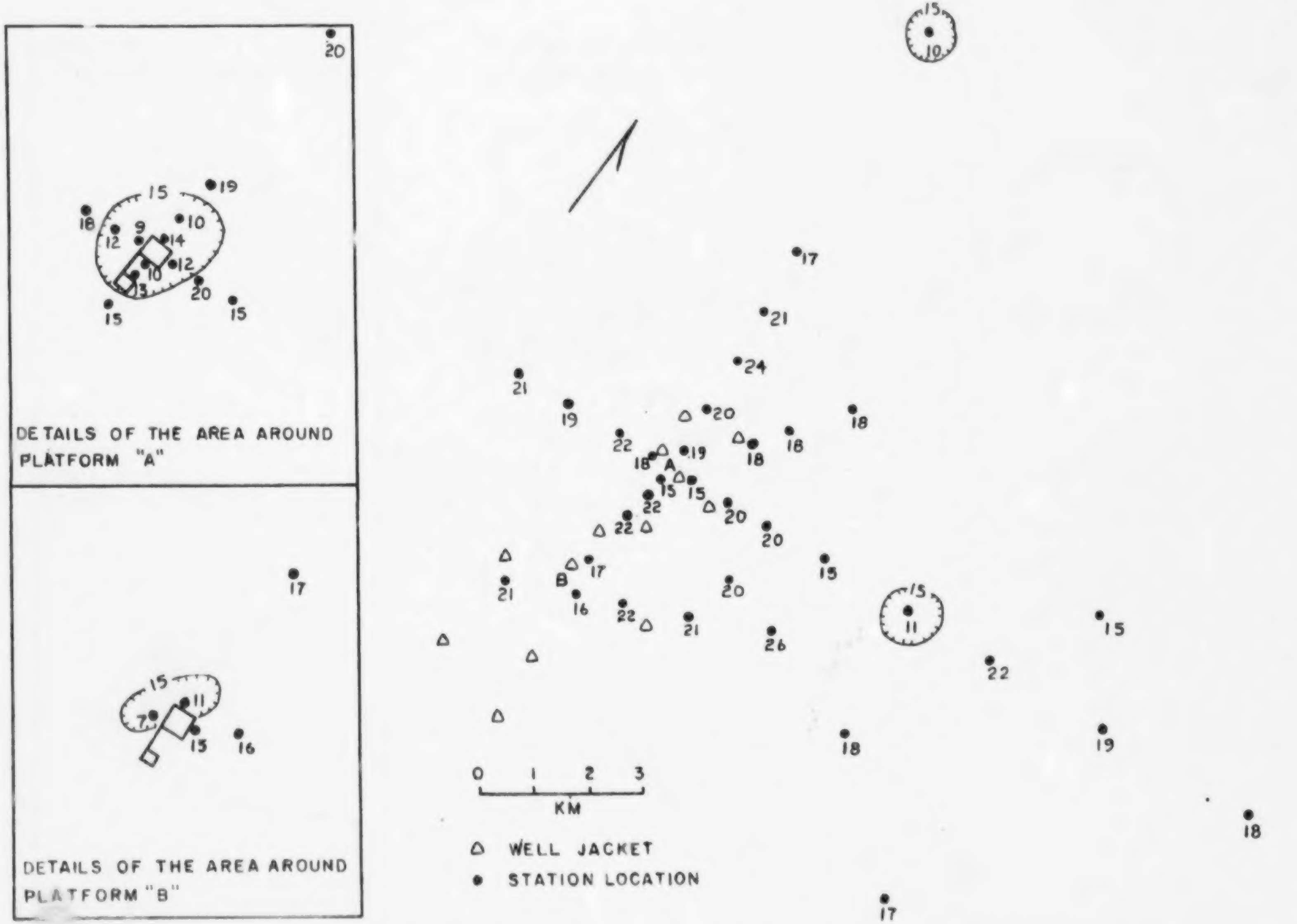
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
A
B
0
1
2
3
KM
△ WELL JACKET
● STATION LOCATION

Figure 23. Map of the Buccaneer Field study area showing the areal distribution of the percentage of species recurring 4 times/total number of species at each station. Suggested isopleths are superimposed.

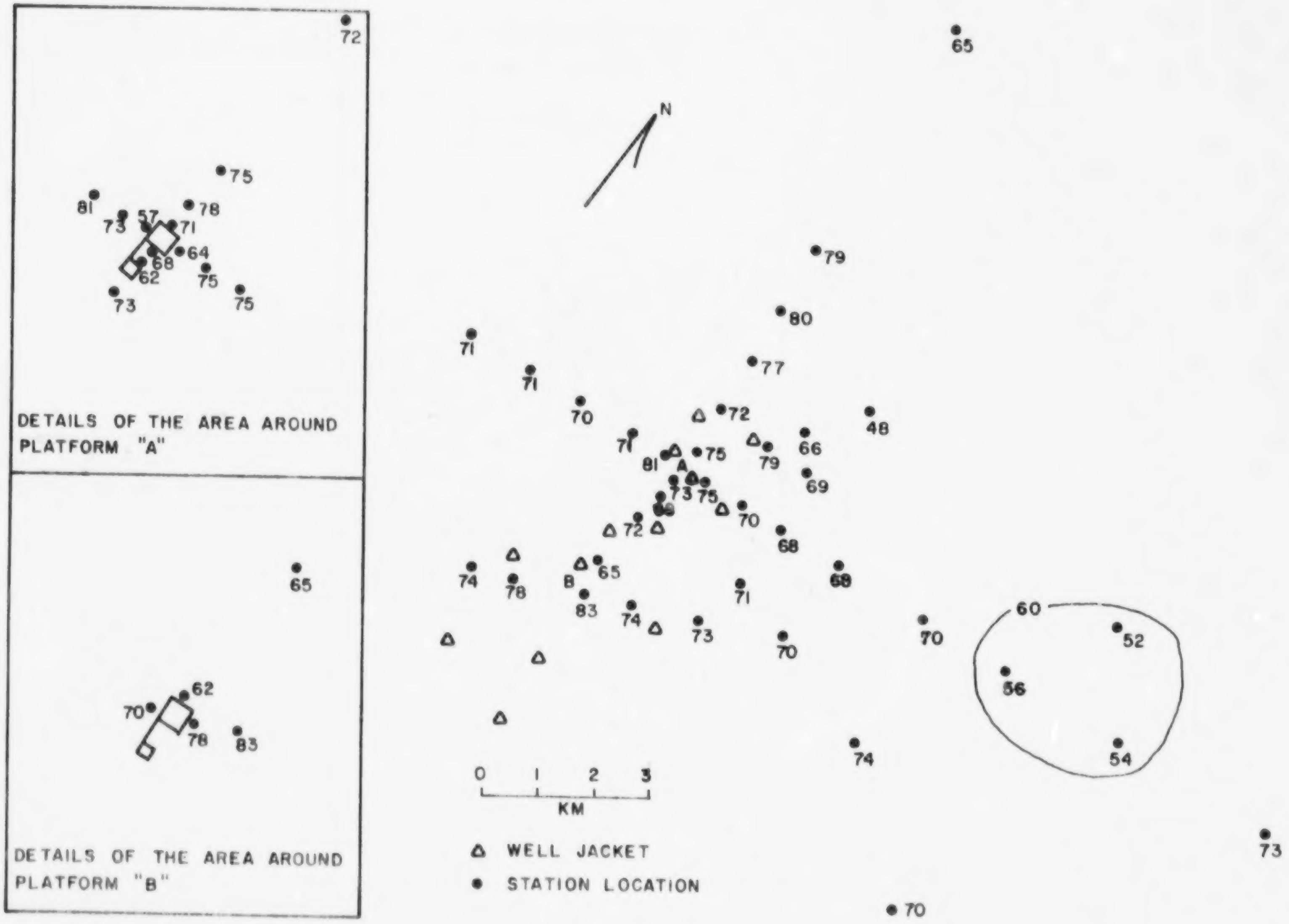
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
0
1
2
3
KM
△ WELL JACKET
● STATION LOCATION
A
B
60
72
75
81
73
57
78
71
64
68
62
73
75
75
65
70
62
78
83
65
79
80
71
77
71
70
72
48
66
79
69
70
68
68
74
78
65
83
74
73
71
70
70
52
56
54
74
73
70

Figure 24. Map of the Buccaneer Field study area showing the areal distribution of the percentage of polychaetes in the total macrobenthic population. Suggested isodemes are superimposed.

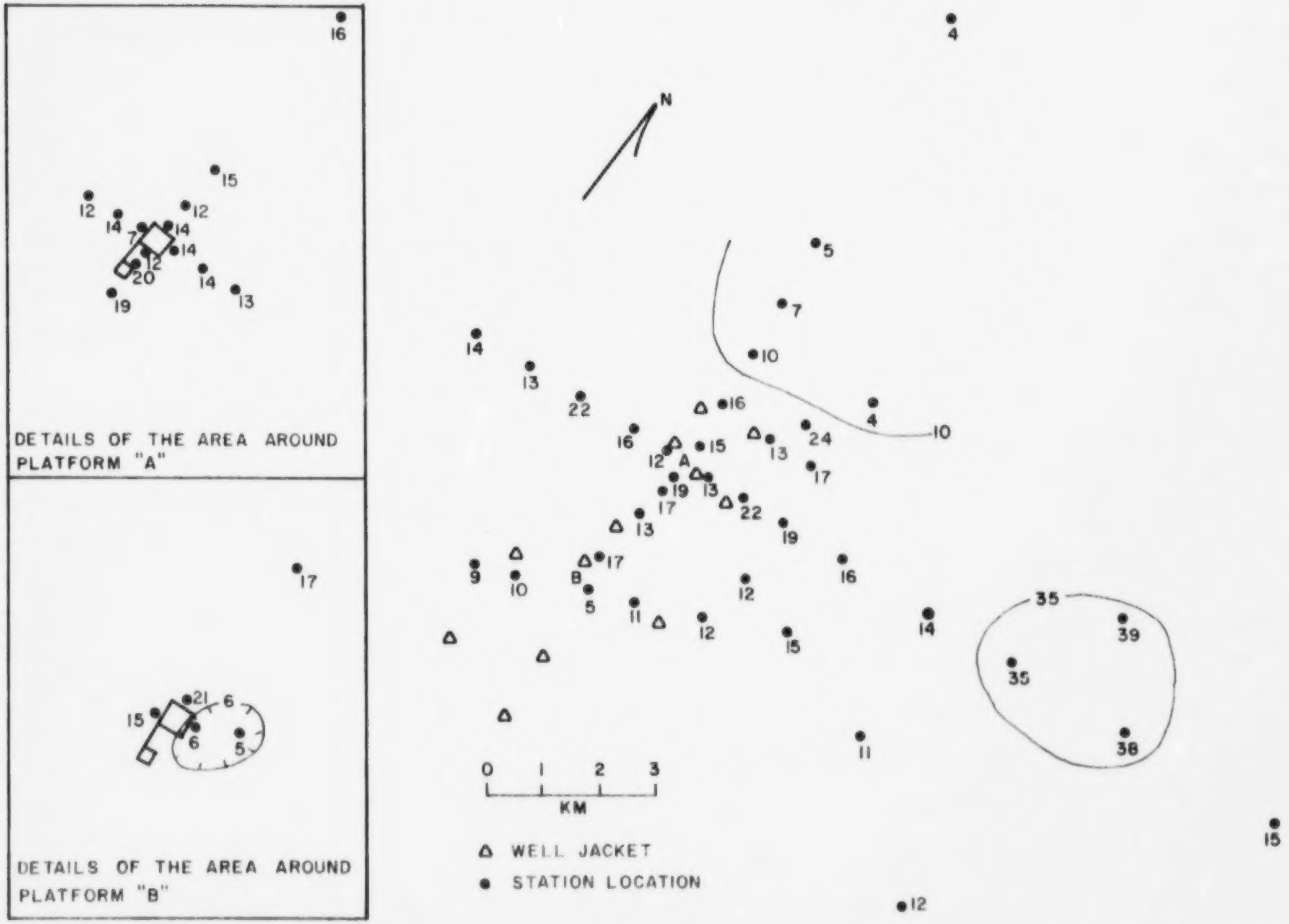
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
A
B
10
35
0
1
2
3
KM
Δ WELL JACKET
● STATION LOCATION

Figure 25. Map of the Buccaneer Field study area showing the areal distribution of the percentage of amphipods in the total macrobenthic population. Suggested isodemes are superimposed.

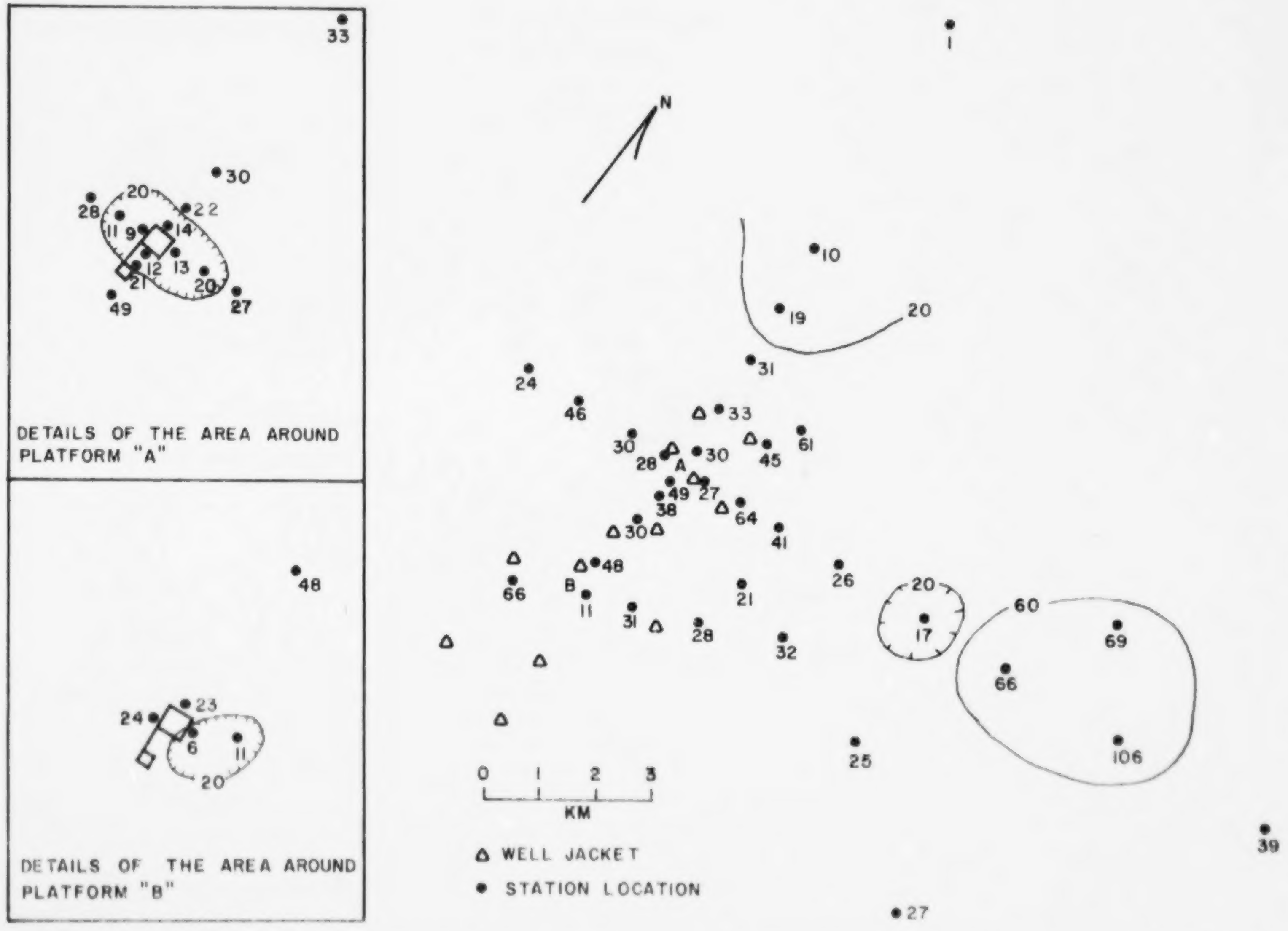
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
0
1
2
3
KM
A
B
20
60
WELL JACKET
STATION LOCATION

Figure 26. Map of the Buccaneer Field study area showing the areal distribution of the *Ampelisca abdita* population. Suggested isodemes are superimposed.

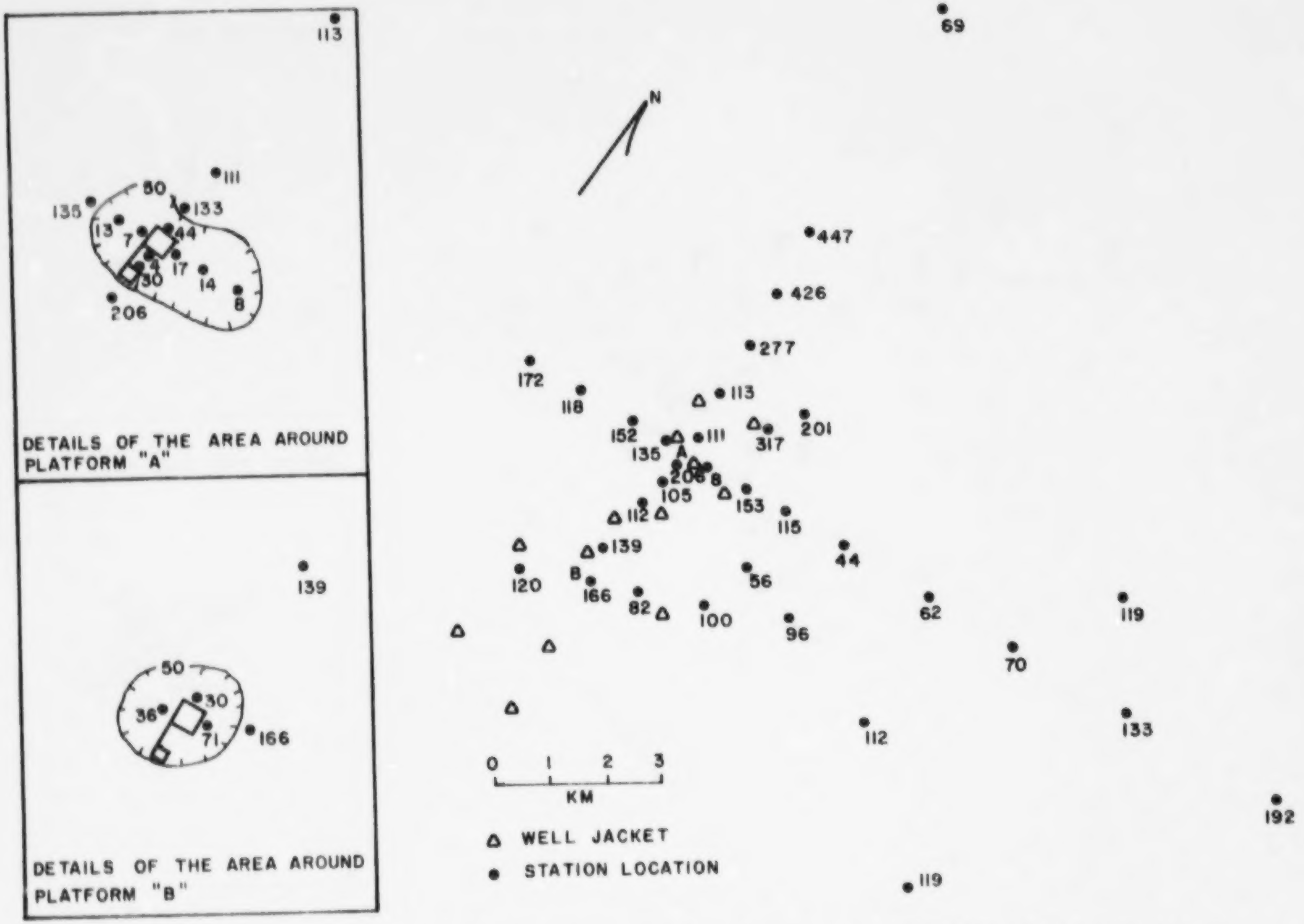
DETAILS OF THE AREA AROUND PLATFORM "A"
113
111
135
50
133
13
7
44
17
30
14
8
206
DETAILS OF THE AREA AROUND PLATFORM "B"
139
50
36
30
71
166
N
69
447
426
277
172
118
113
152
317
201
135
111
A
206
8
105
153
112
115
139
44
120
B
166
56
82
100
62
119
96
70
112
133
192
119
0
1
2
3
KM
WELL JACKET
STATION LOCATION

Figure 27. Map of the Buccaneer Field study area showing the areal distribution of the *Magelona* sp. population. Suggested isodemes are superimposed.

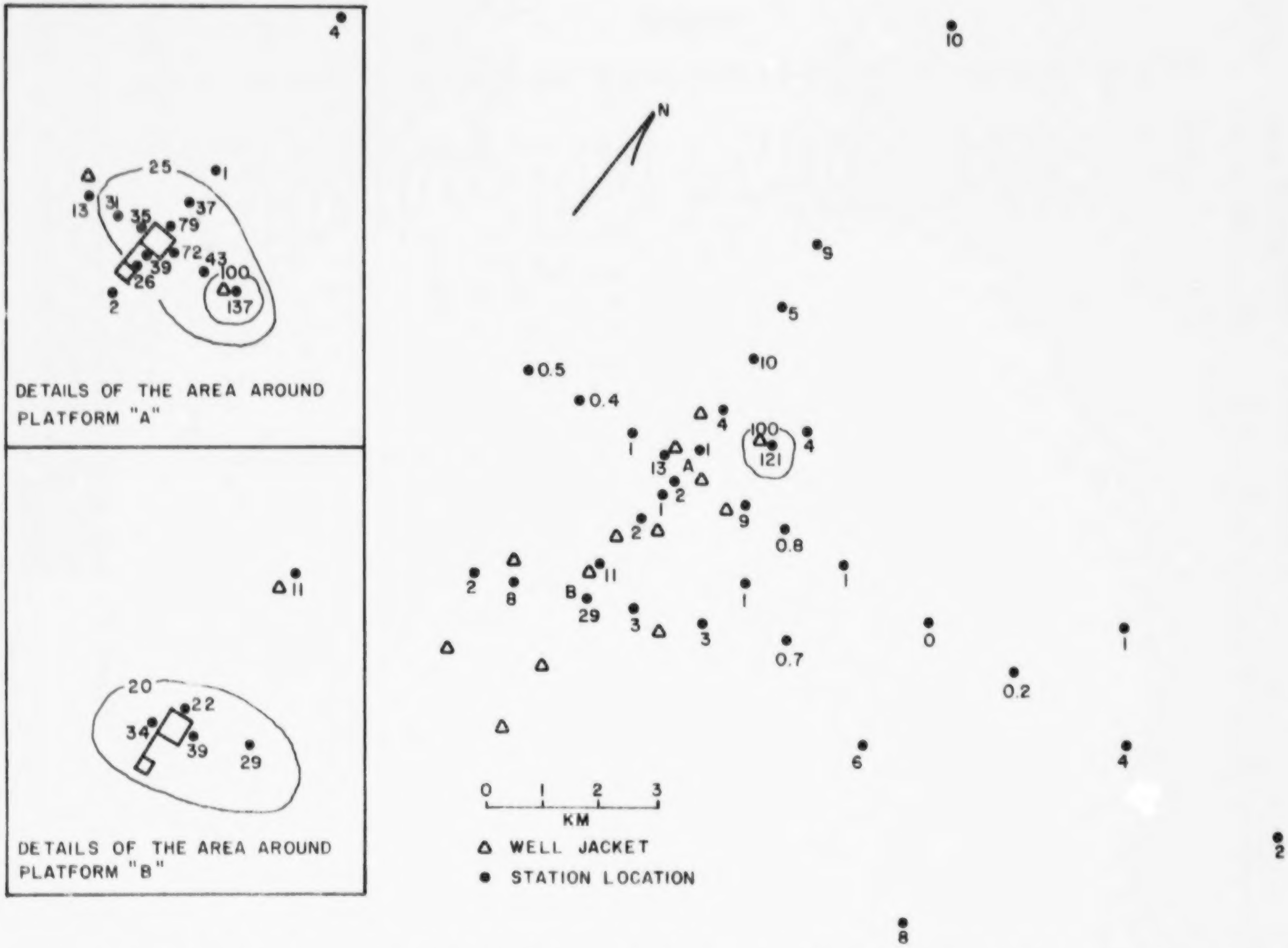
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
0 1 2 3
KM
Δ WELL JACKET
● STATION LOCATION
A
B
25
13
31
35
79
37
1
72
43
100
137
39
26
2
4
20
22
34
39
29
11
10
9
5
10
0.5
0.4
4
1
13
1
2
1
2
100
121
4
9
0.8
2
8
11
29
3
3
1
1
0
0.7
1
0.2
6
4
2
8

Figure 28. Map of the Buccaneer Field study area showing the areal distribution of pteropod shells (total number of shells x 100) in the sediments. Suggested isodemes are superimposed.

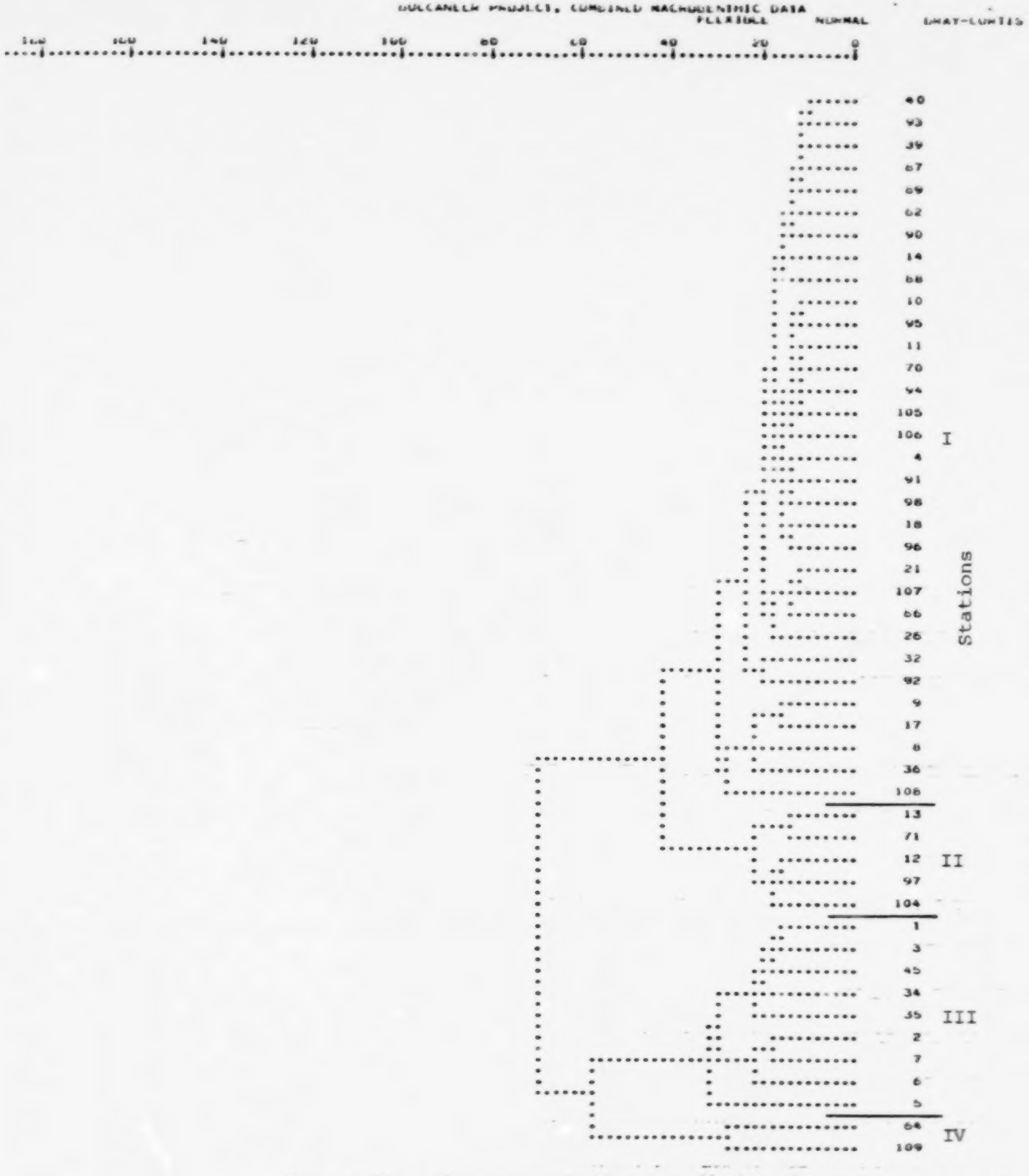

Figure 29. Site group dendrogram produced by numerical analysis of the total macrobenthic data using 67 species, $\sqrt{n}$ transformation, Bray-Curtis dissimilarity measure and flexible sorting.

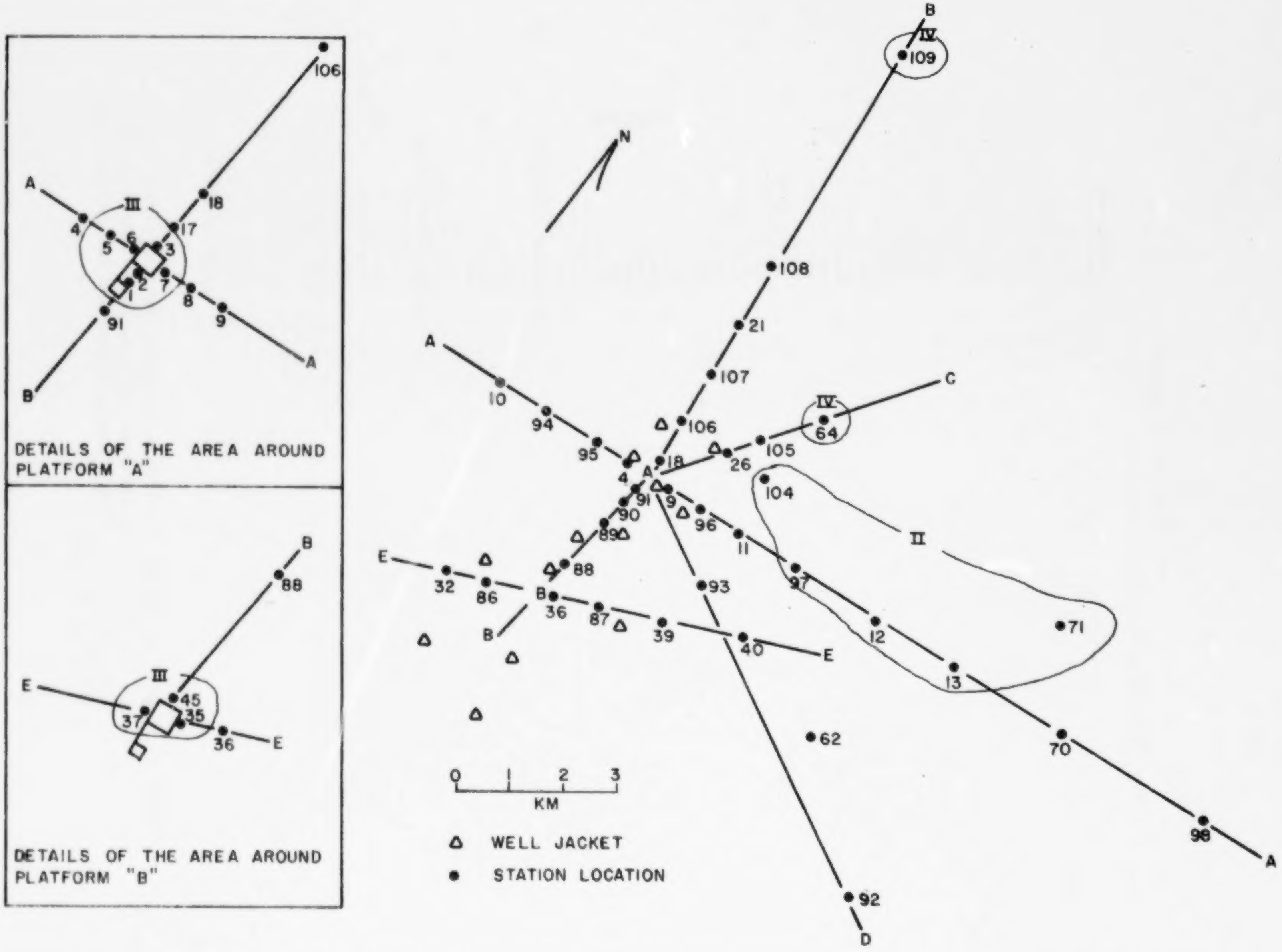
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
A
B
C
D
E
III
II
IV
N
0 1 2 3
KM
Δ WELL JACKET
● STATION LOCATION
1
2
3
4
5
6
7
8
9
10
11
12
13
17
18
21
26
32
35
36
37
39
40
45
62
64
70
71
86
87
88
89
90
91
92
93
94
95
96
97
98
104
105
106
107
108
109

Figure 30. Map of the Buccaneer Field study area showing the station locations and the areal extent of the site groups derived from numerical analysis of the macrobenthic data.

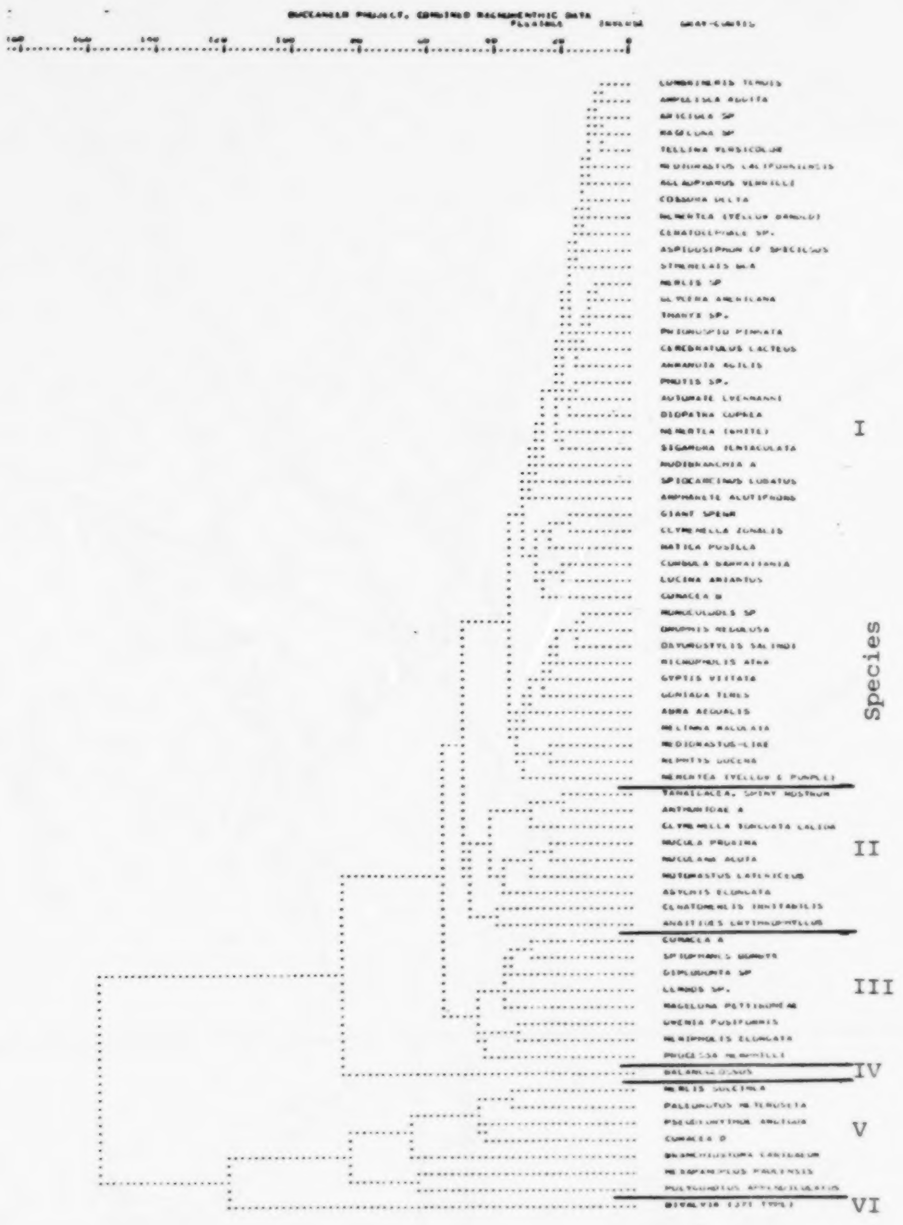
BUCCANEER PROJECT, COMBINED MACROBENTHIC DATA
FLEXIBLE
BRAY-CURTIS
180
160
140
120
100
80
60
40
20
0
LUMBRINERIS TENUIS
AMPELISCA ABDITA
ARICIDEA SP
MAGELONA SP
TELLINA VERSICOLOR
MEDIOMASTUS CALIFORNIENSIS
AGLAOPHAMUS VERRILLI
COSSURA DELTA
NEMERTEA (YELLOW BANDED)
CERATOCEPHALE SP.
ASPIDOSIPHON CF SPECIOSUS
STHENELAIS BOA
NEREIS SP
GLYCERA AMERICANA
THARYX SP.
PRIONOSPIO PINNATA
CEREBRATULUS LACTEUS
ARMANDIA AGILIS
PHOTIS SP.
AUTOMATE EVERMANNI
DIOPATRA CUPREA
NEMERTEA (WHITE)
SIGAMBRA TENTACULATA
NUDIBRANCHIA A
SPIOCARCINUS LOBATUS
AMPHARETE ACUTIFRONS
GIANT SPERM
CLYMENELLA ZONALIS
NATICA PUSILLA
CORBULA BARRATTIANA
LUCINA AMIANTUS
CUMACEA B
MONOCULODES SP
ONUPHIS NEBULOSA
OXYUROSTYLIS SALINOI
MICROPHOLIS ATRA
GYPTIS VITTATA
GONIADA TERES
ABRA AEQUALIS
MELINNA MACULATA
MEDIOMASTUS-LIKE
NEPHTYS
NEMERTEA (YELLOW & PURPLE)
TANAIDACEA, SPINY ROSTRUM
ANTHURIDAE A
CLYMENELLA TORQUATA CALIDA
NUCULA PROXIMA
NUCULANA ACUTA
NOTOMASTUS LATERICEUS
ASYCHIS ELONGATA
CERATONEREIS IRRITABILIS
ANAITIDES ERYTHROPHYLLUS
CUMACEA A
SPIOPHANES BOMBYX
DIPLODONTA SP
LEMBOS SP.
MAGELONA PETTIBONEAE
OWENIA FUSIFORMIS
HEMIPHOLIS ELONGATA
PROCESSA HEMPHILLI
BALANOGLOSSUS
NEREIS SUCCINEA
PALEANOTUS HETEROSETA
PSEUDEURYTHOE AMBIGUA
CUMACEA D
BRANCHIOSTOMA CARIBAEUM
HEXAPANOPEUS PAULENSIS
POLYGORDIUS APPENDICULATUS
BIVALVIA
I
Species
II
III
IV
V
VI

Figure 31. Species group dendrogram produced by numerical analysis of the total macrobenthic data using 67 species, $\sqrt{n}$ transformation, Bray-Curtis dissimilarity measure and flexible sorting

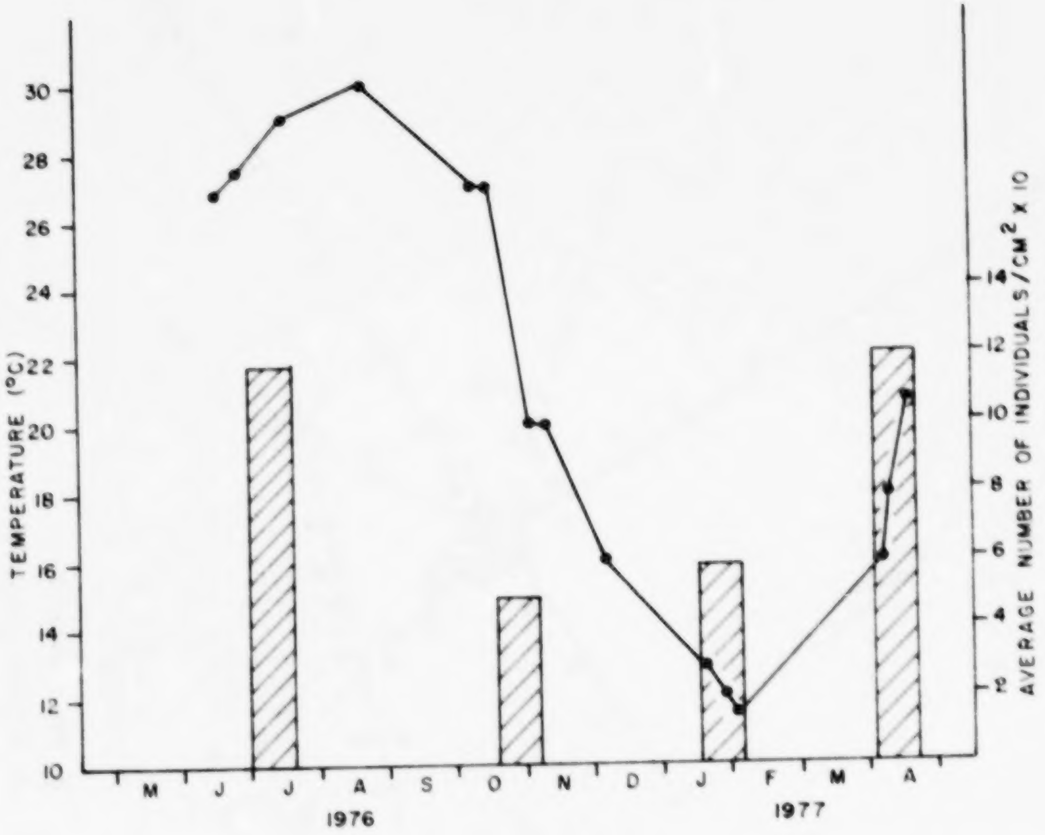

Figure 32. Comparison of the meiobenthic population and sediment temperature trends in the Buccaneer Field study area.

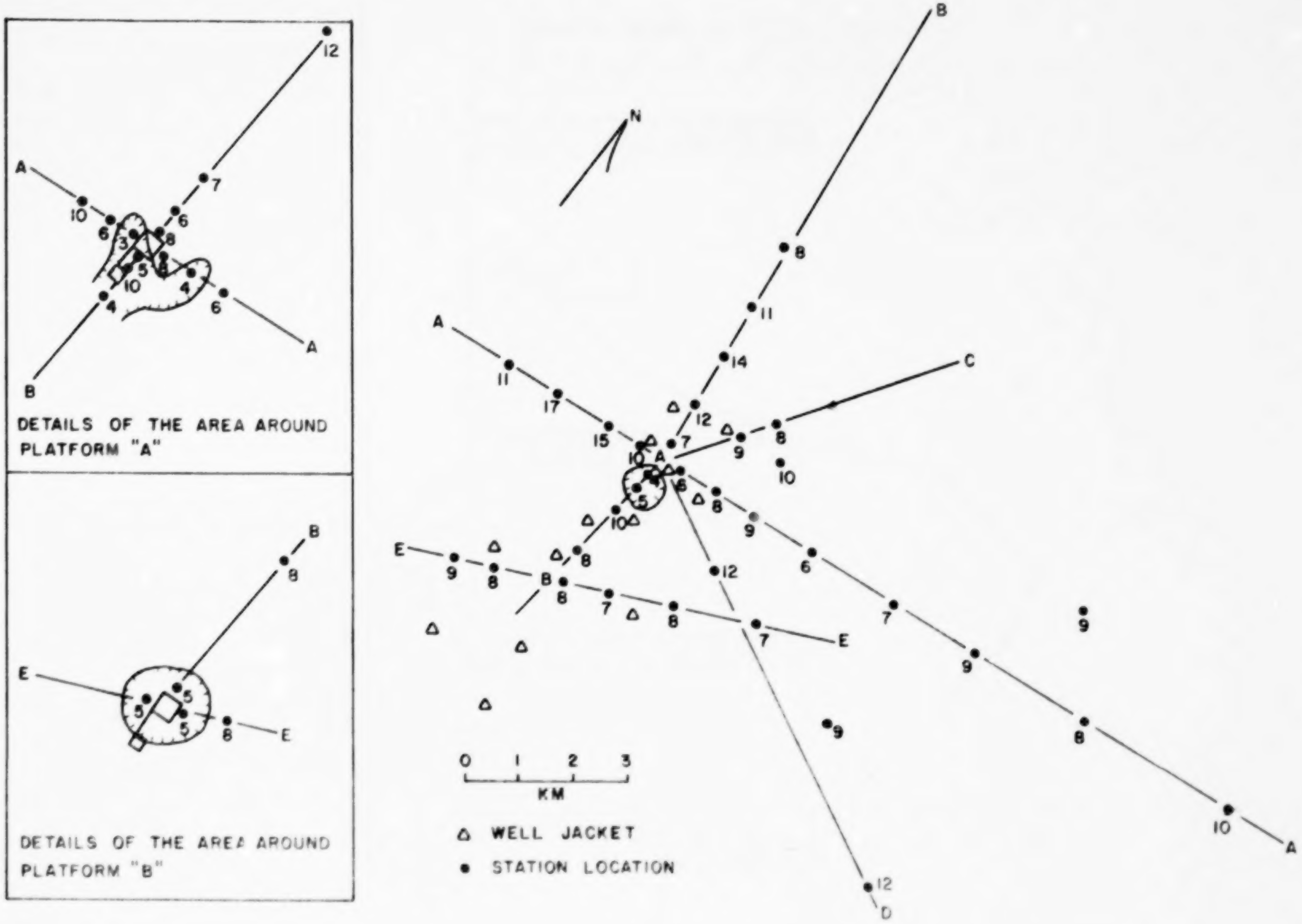
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
A
B
C
D
E
0
1
2
3
KM
△ WELL JACKET
● STATION LOCATION

Figure 33. Map of the buccaneer Field study area showing the areal distribution of the meiobenthic populations (average number of individuals/cm^2 per quarter x 10). Suggested isodemes are superimposed.

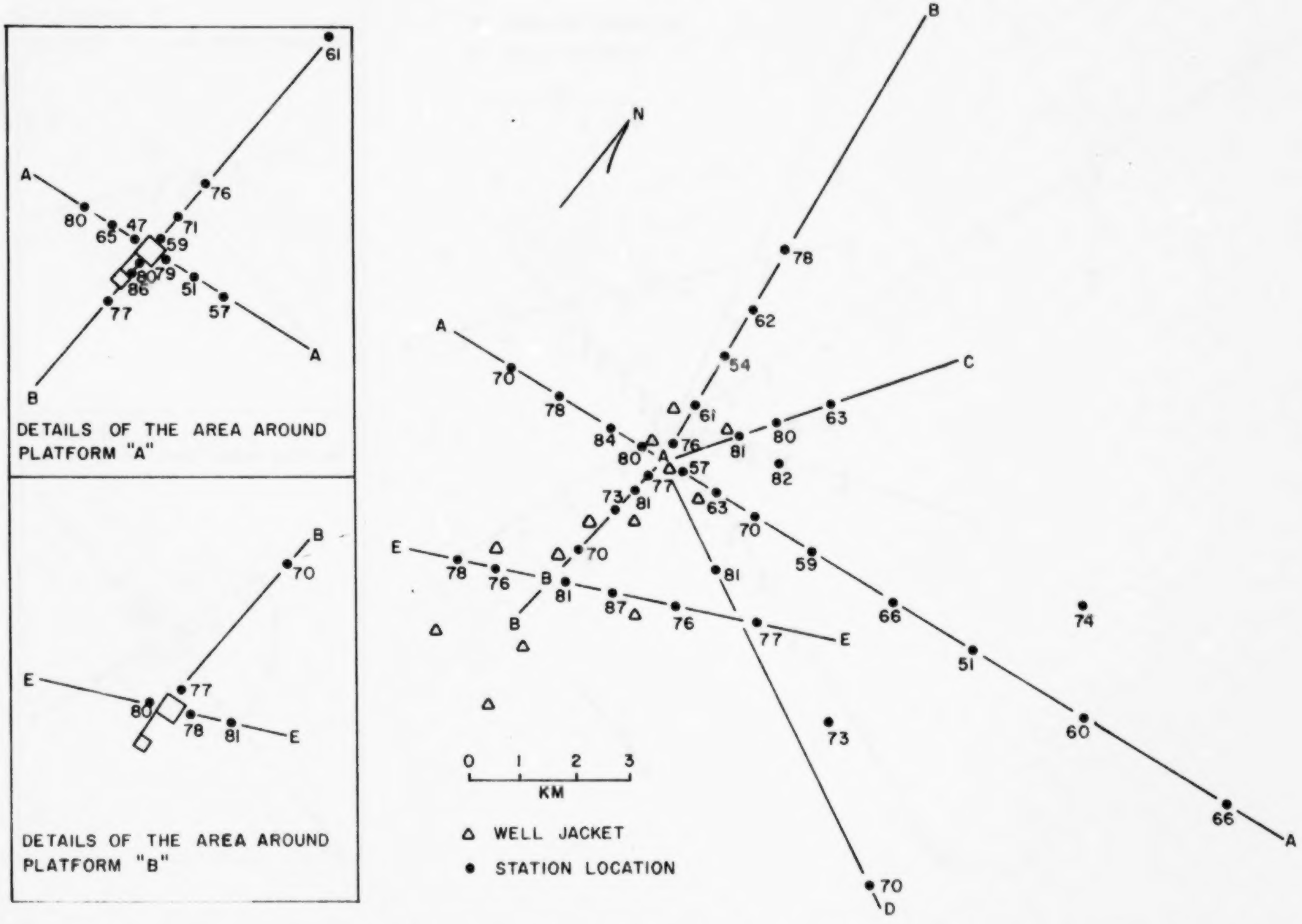
DETAILS OF THE AREA AROUND PLATFORM "A"
A
B
61
76
71
59
79
51
57
80
65
47
80
86
77
DETAILS OF THE AREA AROUND PLATFORM "B"
B
E
70
77
80
78
81
N
A
B
C
D
E
70
78
84
80
76
57
77
73
81
70
61
54
62
78
81
80
63
82
63
70
59
66
51
60
66
81
77
76
87
81
76
78
74
73
70
0
1
2
3
KM
△ WELL JACKET
● STATION LOCATION

Figure 34. Map of the Buccaneer Field study area showing the areal distribution of the percentage of nematodes in the total meiobenthic population.

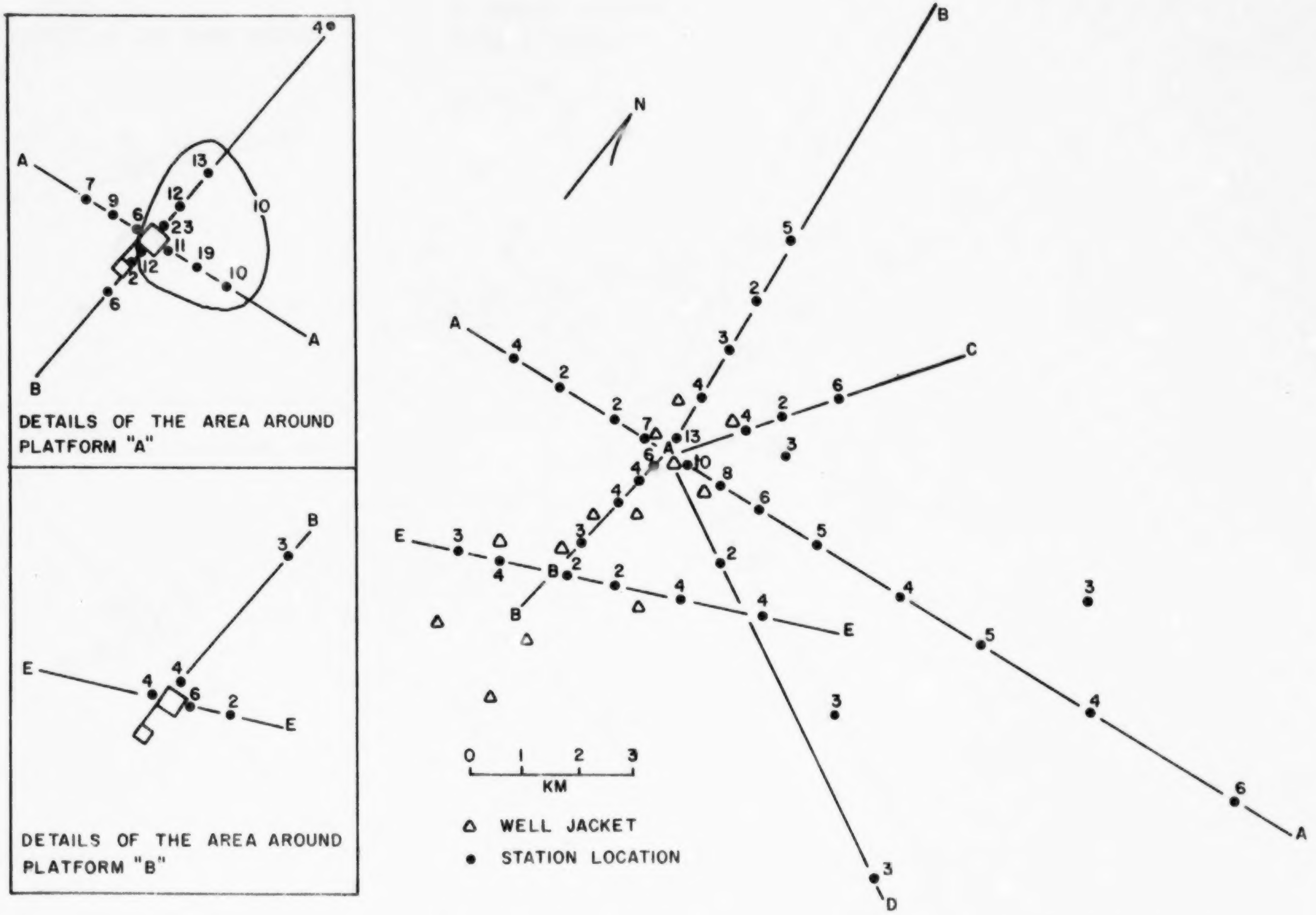
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
0
1
2
3
KM
△ WELL JACKET
● STATION LOCATION
A
B
C
D
E

Figure 35. Map of the Buccaneer Field study area showing the areal distribution of the percentage of Foraminifera in the total meiobenthic population. Suggested isodemes are superimposed.

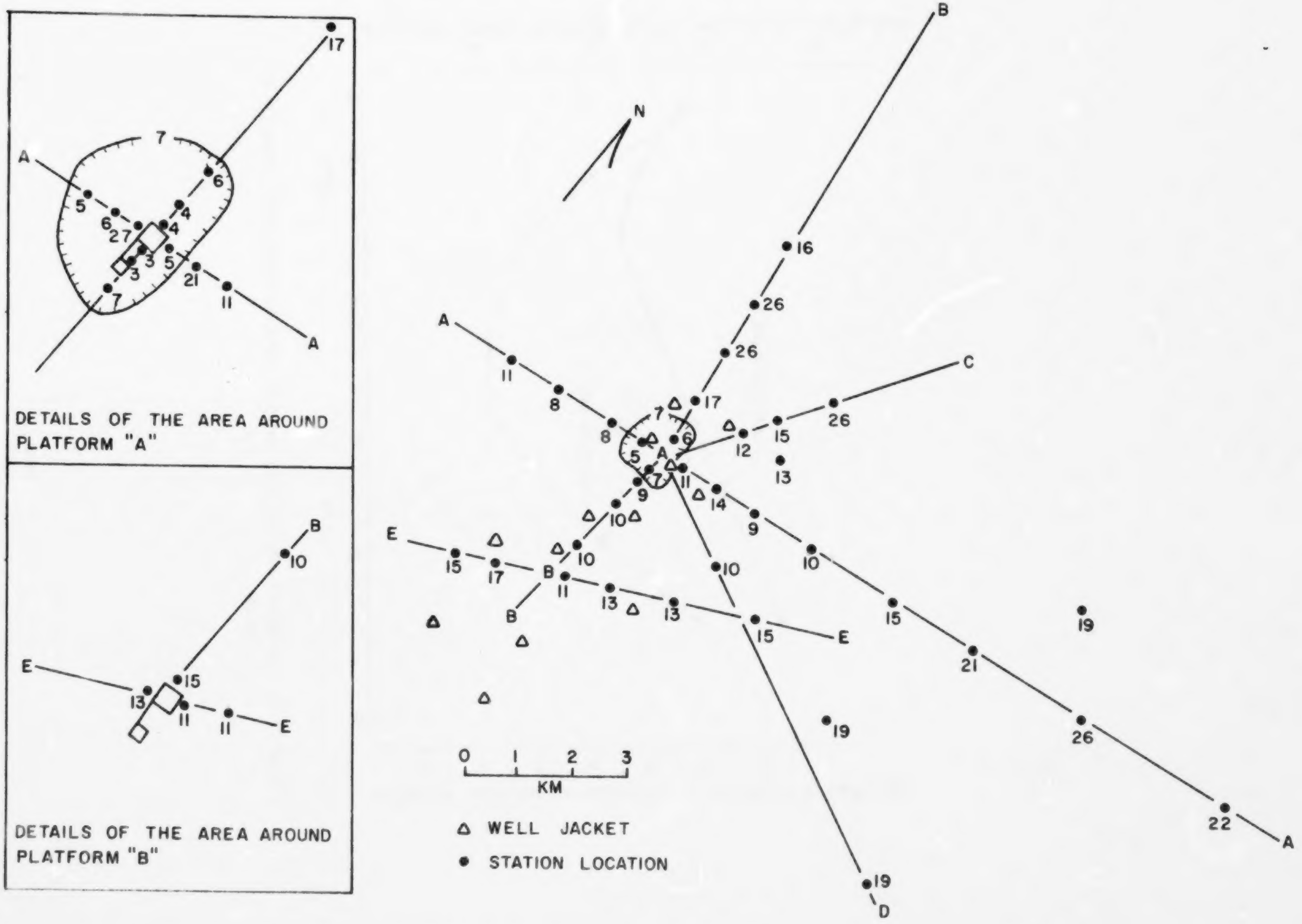
DETAILS OF THE AREA AROUND PLATFORM "A"
DETAILS OF THE AREA AROUND PLATFORM "B"
N
0 1 2 3
KM
△ WELL JACKET
● STATION LOCATION
A
B
C
D
E

Figure 36. Map of the Buccaneer Field study area showing the areal distribution of the percentage of harpacticoid copepods in the total meiobenthic population. Suggested isodemes are superimposed.

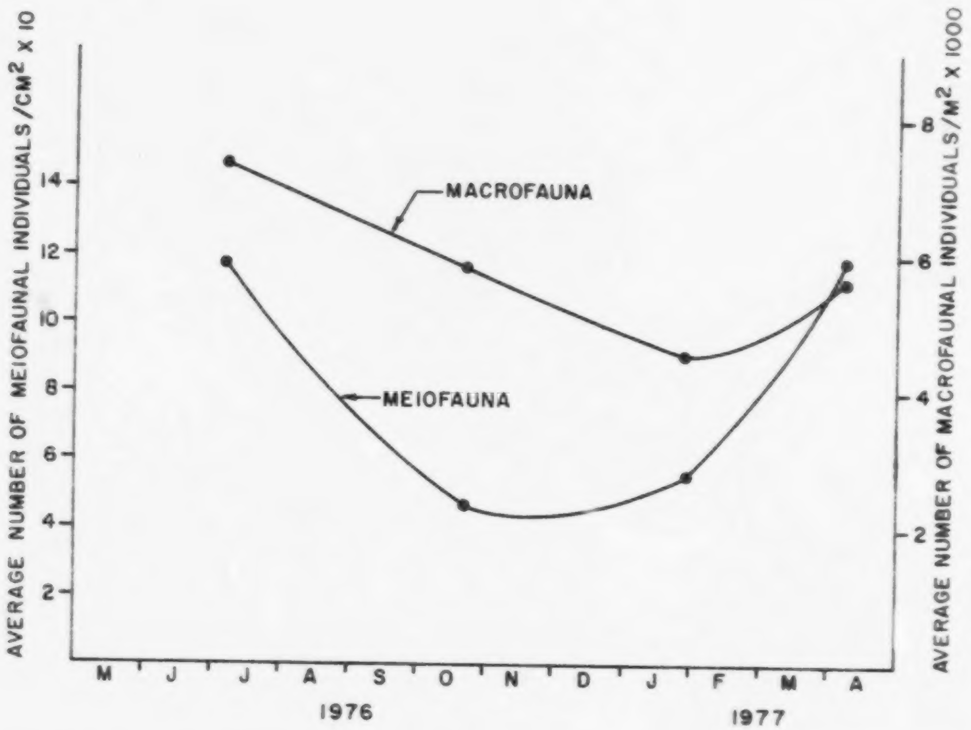

Figure 37. Comparison of the macro- and meiobenthic population trends.

APPENDIX A

Table A1. List of species collected during the Buccaneer Field study, July 1976 through April 1977. *Single occurrence

	Remarks
Phylum Protozoa	
Foraminifera*	
Foraminifera A	
Phylum Porifera	
Hexactinellida(?)*	Questionable
Porifera (Red Spicules)(?)	Questionable; young Renilla(?)
Phylum Cnidaria	
Class Hydrozoa	
Clytia coronata	
Clytia cylindrica	
Clytia elongata	
Lovenella gracilis	
Lovenella grandis	
Obelia dichotoma	
Class Anthozoa	
Anemone un id	
Anemone (brown spot rim)	
Anemone (holothuroid-like)	
Anemone (sand encrusted)	
Anemone (tubular)	
Astrangia astraeiformis	
Renilla(?)*	
Phylum Platyhelminthes	
Class Turbellaria	
Polycladida*	
Stylochus ellipticus	
Turbellaria (brown stripes)*	
Turbellaria	
Turbellaria (crossed eyes)	
Turbellaria (black spots)	
Turbellaria (dark margin)*	
Phylum Nemertea	
Cerebratulus lacteus	
Cerebratulus luridus	
Nemertean*	
Nemertea (broad brown bands)*	
Nemertea (brown band)*	
Nemertea (gray bands)*	
Nemertea (red banded)	
Nemertea (red and yellow)*	
Nemertea (rust colored)*	
Nemertea (white)	
Nemertea (yellow and brown)	

Table A1 (Continued)

	Remarks
Phylum Nemertea (continued)	
Nemertea (yellow and purple)	
Nemertea (yellow banded)	
Phylum Nematoda	
Nematoda	Several species
Phylum Bryozoa	
Bryozoan sp. A	
Bugula neritina	
Cupuladria canariensis	
Membranipora crustulenta	
Phylum Phoronida	
Phoronis architecta	
Phylum Brachiopoda	
Glottidia pyramidata	
Phylum Mollusca	
Class Gastropoda	
Acteon punctostriatus	
Anachis avera	
Anachis obesa	
Bubble Shell*	
Bulla-like opisthobranch	
Caecum glabrum	
*Caecum imbricatum**	
Cantharus cancellarius	
Crepidula fornicata	
Crepidula sp.	Probably young *C. fornicata*
Cyclostremella humilis	
*Epitonium angulatum**	
*Epitonium novangliae**	
Gastropod un id	
*Mangelia atrostyla**	
*Mangelia oxytata**	
Mangelia sp.	
Melanella arcuata	
Melanellidae*	
Nassarius acutus	
Natica pusilla	
Nudibranchia (black stripes)*	
Nudibranchia A	
Nudibranchia B*	
Olivella dealbata	
*Pyramidella crenulata**	
Pyramidellidae*	
Retusa canaliculata	

Table A1 (continued)

	Remarks
Class Gastropoda (continued)	
*Selia adamsi**	
Sinum maculatum	
Strombiformis bilineata	
Teinostoma parvicallum	
Terebra protexta	
Terebra sp.*	
*Thais haemastoma**	
Turbonilla cf. *portoricana*	
Turbonilla interrupta	
Turbonilla sp.*	
Turbonilla, brown suture	
Vitrinella helicoidea (?)	Possibly *Cyclostremella humilis*
*Vitrinella texana**	
Vitrinellidae	2-3 species
Volvulella persimilis	
Volvulella texasiana	
Cavolina Pteropod Shells	
Creseis Pteropod Shells	
Class Bivalvia	
Abra aequalis	
*Agripoma texasiana**	
Anadara leinosa	
Anadara transversa	Possibly *A. lienosa*
*Atrina seminuda**	
Atrina sp.*	Probably young *A. seminuda*
Bivalvia (dirty ventrum)	
Bivalvia (flat, ridged)*	
Bivalvia (371 type)	
Bivalvia un id	Several species
Bivalvia, larger than shell	
Cardiomya costatella	
*Cardiomya ornatissima**	Probably *C. costatella*
Chama congregata	
Chione clenchi	
Chione grus	
Chione sp.	Probably young *C. clenchi*
Corbula barrattania	
*Corbula contracta**	
Corbula krebsiana	
Corbula sp.	
Corbula swiftiana	
Crassinella lunulata	
Cyclinella tenuis	
Diplodonta sp.	
Diplondonta semiaspera	
*Dosinia discus**	Should be *D. elegans*
Doninia elegans	ID questionable; all young specimens

Table A1 (continued)

	Remarks
Class Bivalvia (continued)	
Gemma purpurea	
Jouannetia quillingi	
Laevicardium mortoni	
Lima pellucida	
Lioberius castaneus	
Lucina amiantus	
Lyonsia hyalina floridana	
Macoma sp.*	
*Macoma tageliformis**	
Macoma tenta	
*Mactra fragilis**	
*Mercenaria campechensis**	Young, ID questionable
Mollusca (Micro Sp. 1)	Young bivalves
Mollusca (Micro Sp. 2)*	Young bivalves
*Mulinia lateralis**	
Mysella planulata	
Mytilidae	Possibly young *Lima pellucida*
Noetia ponderosa	
Nuculana acuta	
Nuculana concentrica	
Nuculana proxima	
Parvilucina multilineata	
Pholadidae*	
Semele bellastriata	
Semele proficua	
Semele purpuracens	
Strigilla mirabilis	
Tellina aequistriata	
Tellina sp. A*	
Tellina versicolor	
Tellinidae*	Very small specimens
*Trachycardium muricatum**	
Varicorbula operculata	
Veneridae	
Class Scaphopoda	
*Dentalium texasianum**	
Phylum Annelida	
Class Polychaeta	
Aglaophamus verrilli	
Amaeana trilobata	
Ampharete acutifrons	
Ampharete sp.	
Ampharete (eyes)	
Amphictis scaphobranchiata	
Anaitides erythrophyllus	
*Anaitides mucosa**	
Ancistrosyllis (post frag.)	

Table A1 (continued)

	Remarks
Class Polychaeta (continued)	
Ancistrosyllis hartmanae	
Ancistrosyllis jonesi	
Ancistrosyllis papillosa	
Ancistrosyllis sp. A	
Aricidea fragilis	
Armandia maculata	Should be *A. maculata*
Asychis elongata	
Autolytus sp.*	
Capitella capitata	
Ceratocephale sp.	
Ceratonereis irritabilis	
Chaetopterus variopedatus	
*Chaetozone setosa**	
Chaetozone sp. (frag.)	
Chloeia viridis	
*Chone duneri**	
Chone sp.*	Probably *C. duneri*
Cirratulidae	
Cirratulid (Ventral Groove)	
Cirratulus hedgpethi	
Clymenella sp., (fragment)	
Clymenella torquata calida	
Clymenella zonalis	
Cossura delta	
Diopatra cuprea	
Drilonereis longa	
Drilonereis magna	
Eteone heteropoda	
Eteone lactea	
Eumida sanguinea	
Eunice antennata	
Eunoe sp.	
Glycera americana	
Glycera sp.*	Probably young *G. americana*
Glycinde solitaria	Should be *Goniada teres*
Goniada teres	
Grubeulepis sp.	
Grubeulepis fimbriata	
Gyptis vittata	
*Harmothoe aculeata**	
Hydroides dianthus	
Hydroides protulicula	
Jasmineria bilobata	
*Laonice cirrata**	
Lepidasthenia sp.	
Lepidonotus sublevis	
Lumbrineris tenuis	
Magelona, serrate prostomium	
Magelona pettiboneae	

Table A1 (continued)

	Remarks
Class Polychaeta (continued)	
Magelona riojai	
Magelona rosea	
Magelona sp.	
Malacoceros sp.	
Maldanidae*	
Marphysa, cmpd. falc. and spin.*	
Marphysa regalis	
Marphysa sanguinea	
Mediomastus californiensis	
Mediomastus-like	
Megalomma bioculatum	
Melinna maculata	
Mesochaetopterus taylori	
Microspio pigmentata	
Myriowenia cf. *californiensis*	
Nephtys bucera	
Nephtys incisa	
Nephtys magellanica	
Nephtys picta	
Nereid (un id)*	
Nereiphylla fragilis	
Nereis (gills)*	
Nereis sp.	
Nereis succinea	
Ninoe nigripes	
Notomastus hemipodus	
Notomastus latericeus	
*Onuphidae**	Probably *O. nebulosa*
Onuphis eremita oculata	Should be *O. nebulosa*
Onuphis nebulosa	
*Ophelina cylindrica**	
Ophiodromus obscura	
Owenia fusiformis	
Paleonotus heteroseta	
*Parahesione luteola**	
Paranaitis speciosa	
Pectinaria gouldii	
Pherusia inflata	
*Phyllodoce castanea**	
Pilargis pacifica	
Pista cristata	
Pista palmata	
Pista sp.*	Young of *P. cristata* or *P. palmata*
Poecilochaetus johnsoni	
Polychaeta	
Polydora ligni	
Polydora socialis	

Table A1 (continued)

	Remarks
Class Polychaeta (continued)	
Polydora sp.	
Polynoidae	
Polynoidae, bristly	
Polyodontes lupina	
Prionospio dayi	
Prionospio pinnata	
Prionospio sp.	3-5 Species
Pseudeurythoe ambigua	
*Sabellaria heteroseta**	
Sabellaria vulgaris vulgaris	
Sabellidae	
Scaleworm un id	
Schistomeringos rudolphi	
Scoloplos foliosus	
Scoloplos fragilis	
Scoloplos (Leodamus) rubra	
Sigambra tentaculata	
Sigambra wassi	
Spiochaetopterus oculatus	
Spionidae	
Spionidae, 4 branchiae*	
Spiophanes bombyx	
*Spio setosa**	
Sthenelais boa	
Streblospio benedicti	
Syllidae sp.	Several species
*Syllis gracilis**	ID uncertain
Syllis hyalina	ID uncertain
Terebellidae*	
Terebellides stroemi	
Tharyx sp.	
Thelepis setosus	
Worm (?)*	
Class Archiannelida	
Polygordius appendiculatus	
Phylum Sipunculida	
Aspidosiphon cf. *speciosus*	
Phascolion strombi	
Phylum Echiuroida	
Echiuroidea cf. *Thalassema**	
Phylum Arthropoda	
Class Crustacea	
Subclass Ostracoda	
Ostracoda B	
Ostracoda C	

Table A1 (continued)

	Remarks
Subclass Ostracoda (continued)	
Ostracoda D	
Ostracoda E	
Ostracoda F	
Ostracoda G	
Ostracoda H	
Ostracoda I	
Ostracoda J	
Ostracoda K	
Ostracoda L	
Ostracoda M*	
Ostracoda N	
Ostracoda O*	
Subclass Copepoda	
Canuella sp.*	
Subclass Malacostraca	
Order Nebaliacea	
Nebalia sp.	
Order Stomatopoda	
Squilla empusa	
Order Amphipoda	
Ampelisca abdita	
Amphilochus neapolitanus	
Amphipoda sp. 40 A	
Amphipoda 1	
Amphipoda 2	
Amphipoda (black coxa)*	
Amphipoda (corophiid-like)*	Probably *C. acherusicum*
Amphipoda, un id	Several species
Ampithoe sp.	Should be *Lembos* sp.
*Argissa hamatipes**	
Batea cartharinensis	
Caprella equilibra	
Caprella sp.*	
Corophiidae	
Corophium acherusicum	
Hyperiidea	
*Jassa falcata**	
Jassa sp.	Probably young *J. falcata*
Lembos sp.	
Leucothoidae *	
Listriella barnardi	
Listriella sp.	
Lysianassidae*	
Lysina sp. A*	
Monoculodes sp.	

Table A1 (continued)

	Remarks
Order Amphipoda (continued)	
Monoculodes (brown spots)*	
Paracaprella tenuis	
Parametopella texensis	
Paraphoxus sp.*	
Photis (brown spot antenna)	
Photis sp.	
Platyischnopus sp.	
Platyischnopus sp. A	
*Podocerus brasiliensis**	
Synchelidium americanum	
*Tiron tropakus**	
Uniciola irrorata	
Order Isopoda	
Anthuridae A	
Anthuridae, eyes+long antenna	
Edotea sp.*	ID doubtful
*Edotea triloba**	ID doubtful
Erichthonius brasiliensis	
Idoteidae	
Isopoda un id	2 species
Order Tanaidacea	
Tanaidacea, spiny rostrum	
Tanaid, rounded rostrum	
Order Cumacea	
Cumacea A	
Cumacea B	
Cumacea C	
Cumacea D	
Cumacea E	
Cumacea F	
Cumacea (frontal spines)	
Oxyurostylis salinoi	
Order Mysidacea	
Bowmaniella brasiliensis	
Mysidacea (forked telson)	
Promysis atlantica	
Order Decapoda	
Albunea paretii	
Alpheus floridanus	
Automate evermanni	
Axiidae*	
Brachyura*	Young specimen
Brachyura megalops	

Table A1 (continued)

	Remarks
Order Decapoda (continued)	
Callianassa sp.	
Callinectes sapidus	
Callinectes similis	
Callinectes sp.*	Probably young *C. sapidus* or *C. similis*
Caridea A	
*Chasmocarcinus mississippiensis**	
Decapod megalops	
Dromid megalops*	
Euceramus praelongus	
Euryplax nitida	
Goneplacidae*	Probably young *Spiocarcinus lobatus*
Goneplax sp.	
Hepatus epheliticus	Should be *H. pudibundus*
Hepatus pudibundus	
Hepatus sp.	Should be *H. pudibundus*
Hexapanopeus paulensis	
Hippidea*	
Isocheles wurdemanni	
Latreutes parvulus	
Lepidopa benedicti	
Leptochela serratorbita	
Majidae*	
Natantia*	
Neopanope texana	
Nephropsidae*	
Ogyrides limicola	
*Ovalipes guadulpensis**	
Paguridae*	
Paguristes hummi	
Pagurus annulipes	
Pagurus sp.	Several species
Panopeus turgidus	
Parthinopidae (spiny)	
*Pelia mutica**	
Penaeidae (post larva)	
Penaeus cf. *aztecus* post larva	
*Penaeus setiferus**	
Persephona aquilonaris	
Persephona crinata	
Pinnixa cristata	Should be *P. sayana*
*Pinnixa lunzi**	
Pinnixa, oval	
Pinnixa sayana	
*Pinnotheres ostreum**	
Polyonyx gibbesi	
*Porcellana sayana**	

Table A1 (continued)

	Remarks
Order Decapoda (continued)	
Portunidae post larva	
Processa hemphilli	
Raninoides lousianensis	
Shrimp	Several species of Caridea
Sicyonia dorsalis	
Solenocera sp.	
Spiocarcinus lobatus	
Stomatopod pseudozoea	
Trachypeneus similis	
Xanthidae	2-3 species
Class Insecta	
Chironomid A*	Possibly introduced from another project
Class Pycnogonida	
Pycnogonida	
Phylum Echinodermata	
Class Ophiuroidea	
Hemipholis elongata	
Hemipholis-like	Should be young *H. elongata*
Micropholis atra	
Ophiolepis paucispina	
Ophiophragmus moorei	
Ophiophragmus sp.	Probably young *O. moorei*
Ophiuroidea A	Should be *Ophiolepis paucispina*
Ophiuroidea B	
Ophiuroidea un id*	
Class Echinoidea	
Echinoidea	
Echinoidea, lanceolate spines*	
Phylum Hemichordata	
Balanoglossus sp.	
Phylum Cephalochordata	
Branchiostoma caribaeum	
Phylum Chordata	
Bascanichthys teres	
*Bregmaceros atlanticus**	
Gobiidae (larvae)	
*Microdesmus lanceolatus**	
Incertae Sedis	
Giant sperm	
Incertae sedis*	

Table A2. The average number of macrobenthic individuals/m^2 collected at each station in the Buccaneer Field during each quarterly sampling period and for the four quarters combined.

Station	July	Oct.-Nov.	Jan.-Feb.	April	$\bar{X}$
1	5377	1562	2526	2423	2972
2	4832	1950	3553	1436	2943
3	4942	2152	2208	2304	2902
4	6693	5617	4291	8543	6286
5	3216	2221	2121	1109	2167
6	8353	2276	2937	1221	3697
7	6027	1493	3092	1692	3076
8	7044	3219	2765	2039	3766
9	10312	4256	4324	3799	5673
10	3421	5624	4486	10268	5950
11	8119	5373	4459	5349	5825
12	5360	5110	854	2981	3576
13	5775	4715	3141	7756	5347
14	-	12066	6565	7803	8811
17	3823	6288	6380	3940	5108
18	9126	2971	5619	5189	5726
21	8511	9911	7642	5503	7892
26	9680	11477	7937	10872	9992
32	7519	-	5634	7405	6856
34	9540	3397	3305	4186	5107
35	5127	1978	3295	2270	3168
36	8856	6886	3456	6229	6357
39	7777	11968	4987	3327	7015
40	8118	10672	2194	5530	6629
45	4470	1375	3083	3166	3024
62	5359	9536	5463	6509	6717
64	2110	-	9673	2752	4845
70	10432	1066	4345	5890	7183
71	3348	5688	1512	7786	4584
86	10586	7619	10015	15526	10937
87	13207	10846	4773	6218	8761
88	13996	3682	5256	12236	8793
89	8134	5303	5845	5502	6196
90	7994	7024	3985	6521	6381
91	8768	7663	5275	6947	7163
92	9165	5245	4041	5070	5880
93	6215	7145	1827	6761	5487
94	4185	6862	5560	6938	5886
95	4972	6351	4054	6319	5424
96	10212	7136	6393	9960	8425
97	5597	4372	4746	2566	4320
98	10454	9055	2697	5479	6921
104	-	4776	5239	3612	4542
105	7749	8091	3856	8095	6948
106	8266	5917	3013	5218	5604

Table A2 (Continued)

Station	July	Oct.-Nov.	Jan.-Feb.	April	$\bar{X}$
107	7579	8724	9115	9014	8608
108	9707	4169	4803	5446	6031
109	7566	1653	5773	3413	4601

Table A3 The number of species collected at each station in the Buccaneer Field during each quarterly sampling period and for all four quarters combined.

Station	July	Oct.-Nov.	Jan.-Feb.	April	Combined Total
1	68	40	30	38	101
2	74	36	47	33	115
3	48	35	41	43	93
4	45	43	28	39	80
5	32	36	42	26	76
6	60	50	41	30	109
7	61	33	41	41	104
8	56	49	38	28	92
9	54	44	54	38	109
10	46	61	34	61	96
11	62	48	31	40	97
12	40	59	16	40	89
13	42	41	36	36	74
14	-	63	40	53	89
17	55	46	37	47	98
18	52	31	40	35	84
21	61	59	38	44	102
26	62	57	45	52	106
32	59	-	41	50	84
34	62	44	53	38	121
35	46	36	44	28	85
36	51	54	37	53	98
39	55	73	48	36	103
40	66	57	40	45	97
45	48	37	33	44	95
62	44	66	31	46	96
64	29	-	42	38	73
70	45	51	33	41	84
71	46	43	20	29	79
86	58	36	53	62	102
87	71	47	46	54	103
88	66	44	47	51	105
89	63	42	43	48	91
90	49	42	41	48	88
91	49	48	34	49	92
92	59	45	43	54	100
93	56	63	30	51	97
94	37	49	43	39	78
95	46	39	43	44	83
96	56	42	33	41	89
97	58	42	34	42	92
98	63	49	34	38	93
104	-	34	56	39	76
105	45	56	37	49	94
106	49	49	34	39	82

Table A3 (Continued)

Station	July	Oct.-Nov.	Jan.-Feb.	April	Combined Total
107	49	56	46	47	89
108	70	44	35	42	101
109	56	30	48	39	101

Table A4. Faunal stability at each station in the Buccaneer Field study area. Listed are the numbers of species that recurred 4,3,2, and 1 time, the ratio of frequently (4 & 3 occurrences) recurring species to infrequently, (2 and 1 occurrences) species, the ratio of species occurring 4 times to species occurring once, and in the ratio of species occurring 4 times to the total number of species.

Station	4	3	2	1	$\frac{4+3}{2+1}$	$\frac{4}{1}$	$\frac{4}{\text{Total}}$
1	13	8	18	60	269	217	129
2	12	10	20	71	242	169	104
3	13	5	23	49	250	265	140
4	14	10	12	44	429	318	175
5	9	5	22	40	226	225	118
6	10	8	24	58	220	172	092
7	12	8	17	59	263	203	115
8	18	4	17	52	319	346	196
9	16	7	16	65	280	246	147
10	20	12	21	41	516	488	208
11	19	6	14	56	357	339	196
12	10	10	17	51	294	196	112
13	16	8	17	33	480	485	216
14		ONLY THREE COLLECTIONS					
17	10	17	25	41	409	244	102
18	16	7	12	46	397	348	190
21	21	8	21	48	420	438	206
26	19	11	28	44	417	432	179
32		ONLY THREE COLLECTIONS					
34	9	13	22	72	223	125	074
35	13	9	11	49	367	265	153
36	16	11	20	48	397	333	163
39	22	14	13	49	581	449	214
40	21	17	15	40	691	525	216
45	10	11	15	57	292	175	105
62	17	13	17	47	469	362	177
64		ONLY THREE COLLECTIONS					
70	16	10	17	38	473	421	190
71	12	6	15	41	321	293	152
86	21	10	20	49	449	429	206
87	23	13	22	44	545	523	223
88	18	13	23	48	437	375	171
89	20	13	19	37	589	341	220
90	19	9	18	40	483	475	216
91	14	14	18	44	452	318	152
92	17	14	22	45	463	278	170
93	19	14	18	44	532	432	196
94	15	14	13	42	527	357	192
95	18	12	10	39	612	462	217
96	18	8	12	49	426	367	202
97	14	13	15	48	428	297	152

Table A4 (Continued)

	4	3	2	1	$\frac{4+3}{2+1}$	$\frac{4}{1}$	$\frac{4}{\text{Total}}$
98	17	10	19	46	415	370	182
104		ONLY THREE COLLECTIONS					
105	17	15	13	46	540	370	181
106	16	10	20	35	473	457	195
107	21	19	8	39	851	538	236
108	17	13	15	53	441	321	168
109	10	11	20	57	273	175	099

Table A5 Macrobenthic data. July 1976 - April 1977: percent composition by taxon.

	1	2	3	4	5	6	7	8	9	10	11	12
Amphipoda	19.6	11.7	13.5	12.1	13.7	6.8	13.9	13.5	13.3	12.9	19.4	13.8
Anthozoa	0.4	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.1	
Archiannelida		0.4				21.5	0.1					
Bivalvia	2.7	2.8	5.8	2.0	2.3	2.6	1.6	3.2	2.4	4.9	3.7	3.8
Brachiopoda	0.1							0.1		0.1		0.1
Bryozoa					0.2	0.2	0.2	0.1	0.1			
Cephalochordata		0.5	0.1		0.6	0.8	0.8	0.1			0.1	
Copepoda												
Cumacea	0.6	2.6	1.6	0.5	1.3	2.7	2.1	0.6	0.8	0.8	1.8	2.0
Decapoda	3.2	5.8	1.6	0.8	3.7	4.3	6.8	1.2	1.3	1.0	0.5	0.8
Echinoidea						0.1				0.1		
Echiuroida												
Gastropoda	1.1	1.6	1.0	0.6	1.4	1.6	1.7	0.3	0.4	1.2	0.5	0.6
Hemichordata								0.5		0.8		
Hydrozoa								0.3				0.1
Incertae Sedis	0.8		0.4	0.4	0.2	0.2	0.1	0.3	0.1	0.7	0.1	1.8
Insecta												
Isopoda	1.2		0.4	0.1	0.7	0.4		0.3	0.1	0.5	0.1	
Mysidacea		0.1	0.1								0.1	
Nebaliacea		0.2					0.1		0.1			
Nematoda	0.1	0.1	0.1					0.2	0.3	0.2	0.1	0.5
Nemertea	5.0	2.2	1.9	1.6	1.8	4.8	5.3	2.6	2.6	2.6	2.8	3.1
Ophiuroidea	1.1	1.8	1.3	0.1	0.7	1.0	1.7	0.1	0.7	0.3	0.2	0.4
Osteichthys											0.1	
Ostracoda	0.6	0.6	0.5	0.1		0.6	0.5		0.4	0.1	0.3	0.1
Phoronida	0.1										0.1	0.2
Platyhelminthes	0.1	0.2				0.1		0.1				
Polychaeta	62.3	68.2	70.6	81.0	72.6	52.0	64.1	75.4	74.6	71.0	68.0	70.1
Porifera								0.1				
Protozoa												
Pycnogonida												
Scaphopoda												
Sipunculida	0.6	0.8	0.8	0.6	0.5		0.6	0.9	2.3	1.9	1.6	1.4
Stomatopida	0.1				0.3					0.1		
Tanaidacea	0.2	0.1	0.1	0.2		0.2		0.2	0.5	0.7	0.6	1.3

Table A5 (Continued)

	13	14	17	18	21	26	32	34	35	36	39	40
Amphipoda	35.3	14.1	11.6	14.6	6.5	12.6	8.8	14.7	6.2	5.2	11.8	15.4
Anthozoa		0.1	0.1	0.1	0.1		0.1	0.2	0.1	0.1		0.1
Archiannelida			0.1									
Bivalvia	2.7	3.6	2.5	3.8	2.7	2.8	3.0	4.4	2.2	3.9	3.7	3.6
Brachiopoda		0.2				0.1					0.1	
Bryozoa								0.1				
Cephalochordata								0.3	0.7	0.1		0.1
Copepoda												
Cumacea	1.1	1.4	1.6	0.4	1.1	1.4	0.2	3.6	3.6	1.7	0.8	0.5
Decapoda	0.8	0.7	2.0	0.4	0.7	0.6	0.4	2.0	1.7	0.9	1.0	1.1
Echinoidea												
Echiuroida												
Gastropoda	0.7	0.5	0.3	0.9	0.3	0.2	0.2	0.5	0.4	0.3	0.4	0.3
Hemichordata				0.1	0.3		1.3					0.1
Hydrozoa				0.1					0.1			
Incertae Sedis	0.3	0.6	0.1	0.2	1.8	0.3	1.0	0.1	0.3	0.1	0.4	0.3
Insecta							0.1					
Isopoda		0.8	0.1		0.9	0.1	1.8	0.3	2.0	1.0	1.0	0.7
Mysidacea					0.1		0.1				0.1	
Nebaliacea								0.2		0.1		
Nematoda	0.1	1.3	0.3				0.3	0.1		1.0	0.1	
Nemertea	2.1	2.9	2.4	2.8	1.4	1.0	1.6	1.4	1.4	1.3	2.5	3.2
Ophiuroidea	0.1	0.2	0.2	0.2	0.3	0.1		0.6	1.3	0.2	0.6	0.6
Osteichthys				0.1				0.1	0.2			
Ostracoda	0.3	0.3	0.1	0.2	0.2	0.2	0.1	0.6	0.3	0.5	0.5	0.2
Phoronida	0.1			0.1								
Platyhelminthes		0.1						0.1				0.1
Polychaeta	55.7	71.1	77.9	74.9	80.7	79.4	74.0	69.7	77.5	82.8	73.4	69.5
Porifera												
Protozoa								0.1				
Pycnogonida			0.1									
Scaphopoda				0.1								
Sipunculida	0.7	0.7	0.5	1.0	0.1	0.9	1.4	0.7	1.0	0.5	1.1	1.2
Stomatopoda										0.2		
Tanaidacea	0.1	1.3	0.1		2.8	0.1	5.6	0.3	0.8	0.2	2.1	3.0

Table A5. (Continued)

	45	62	64	70	71	86	87	88	89	90	91	92
Amphipoda	20.9	11.4	3.7	38.1	39.2	10.3	11.1	17.3	13.3	16.7	18.9	12.0
Anthozoa			0.2						0.1	0.1		
Archiannelida					0.2							
Bivalvia	4.0	4.6	43.1	2.8	2.6	2.3	4.0	6.3	4.9	6.3	2.8	5.1
Brachiopoda							0.1			0.2		0.1
Bryozoa			0.1									
Cephalochordata	0.3		0.4									
Cumacea	1.7	0.7	0.4	0.6	0.8	0.5	1.0	0.8	0.6	0.5	0.3	1.7
Decapoda	2.1	0.8	0.8	0.8	0.5	0.3	0.7	0.8	0.7	0.8	1.1	0.9
Echinoidea												
Echiuroida												
Gastropoda	1.2	0.4	1.1	0.5	0.6	0.4	0.5	0.4	0.2	0.4	0.6	0.6
Hemichordata						0.1	0.1		0.1	0.1		0.1
Hydrozoa					0.2				0.1	0.1		0.1
Incertae Sedis	0.1	0.6	0.5	0.1	0.1	0.7	0.6	0.3	0.5	0.3	0.1	0.8
Insecta												
Isopoda	1.1	1.9	0.1	0.2	0.2	1.0	1.2	0.8	1.7	0.7	0.1	1.6
Mysidacea												0.1
Nebaliacea	0.2											
Nematoda	0.2	0.3			0.2	0.2	0.5		0.1			0.1
Nemertea	2.4	2.8	0.5	1.8	2.3	1.3	1.7	0.8	1.7	1.7	1.1	1.4
Ophiuroidea	0.8	0.3	0.4	0.1	0.3	0.2	0.4	0.4	0.1	0.1		0.8
Osteichthys		0.1			0.1							0.1
Ostracoda	0.5	0.4	0.5		0.7	0.2	0.4		0.1	1.3	0.1	0.1
Phoronida					0.1							0.1
Platyhelminthes	0.2											
Polychaeta	62.3	73.8	48.2	54.3	52.0	78.4	73.8	65.3	72.0	68.1	73.3	70.2
Porifera												
Protozoa												
Pycnogonida												
Scaphopoda												
Sipunculida	1.1	0.8	0.2	0.3	0.1	0.6	1.7	0.9	1.3	1.0	1.0	0.2
Stomatopoda												
Tanaidacea	0.8	1.3		0.2		3.5	2.0	5.6	3.0	1.9	0.2	3.9

Table A5. (Continued)

	93	94	95	96	97	98	104	105	106	107	108	109
Amphipoda	11.9	21.8	15.7	22.0	16.2	15.1	17.1	23.7	15.9	10.2	5.2	4.6
Anthozoa							0.1				0.1	0.1
Archiannelida						0.3						0.2
Bivalvia	4.7	3.1	5.7	3.0	6.1	2.1	4.9	3.3	3.6	2.7	5.4	4.8
Brachiopoda	0.1	0.1				0.1						
Bryozoa			0.1		0.1							0.1
Cephalochordata							0.1		0.1		0.1	15.1
Cumacea	1.0	0.5	1.0	0.4	0.8	0.9	0.2	1.0	1.1	1.0	2.6	3.8
Decapoda	0.7	1.0	0.6	0.6	0.4	0.9	1.0	0.8	1.5	0.5	0.5	0.4
Echinoidea												
Echiuroida	0.1											
Gastropoda	0.4	0.1	0.6	0.5	1.6	0.4	0.5	0.7	0.4	0.3	0.9	1.3
Hemichordata		0.1	0.1			0.1			0.1			
Hydrozoa					0.1	0.1	0.1					
Incertae Sedia	0.4	0.5	0.9	0.2	0.7	0.8	0.2	0.2	0.6	0.6	0.5	0.8
Insecta												
Isopoda	1.2	0.1	0.3		0.2	0.9		0.2	0.1	0.3	0.3	0.1
Mysidacea											0.1	
Nebaliacea												0.1
Nematoda					0.1	0.3	0.2	0.1				
Nemertea	3.1	1.3	1.3	1.8	4.8	2.0	3.0	2.4	1.8	1.6	1.4	0.4
Ophiuroidea	0.5	0.1	0.1	0.1	0.1	0.1	0.4	0.3	0.4	0.1	0.2	0.6
Osteichthys												
Ostracoda	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.2
Phoronida											0.1	
Platyhelminthes								0.1				
Polychaeta	70.8	69.5	71.1	70.3	68.2	73.4	69.1	66.0	72.3	76.6	79.1	64.6
Porifera								0.1				
Protozoa						0.1		0.1				
Pycnogonida												
Scaphopoda												
Sipunculida	1.6	1.1	1.1	0.8	0.6	0.5	2.7	1.1	1.8	0.4	0.1	1.8
Stomatopoda												
Tanaidacea	3.3	0.7	1.2			1.9			0.1	5.2	3.2	0.1

Table A6. List of meiofaunal species collected during the Buccaneer Field study, July 1976 through April 1977.

- Phylum Protozoa
  - Order Foraminifera
    - *Ammoscalaria* sp.
    - *Angulogerina bella*
    - *Ammonia beccarii*
    - *Bolivina barbata*
    - *Bolivina fragilis*
    - *Caneris* spp. (2)
    - *Cibicides* sp.
    - *Hanzawaia* spp. (2)
    - *Planulina* sp.
    - *Proteonina difflugiformis*
    - *Elphidium* spp. (3)
    - *Bigeneria irregularis*
    - *Buliminella* sp.
    - *Virgulina* sp.
    - *Reusella atlantica*
    - *Reophax* sp.
    - Unidentified foram
    - *Quinqueloculina* spp. (2)
    - *Nonionella* sp.
    - *Angulogerina* sp.
    - *Proteonina comprina*
    - *Spiroloculina* sp.

- Phylum Cnidaria
  - Hydroid

- Phylum Nemertea
  - Nemertean spp.

- Phylum Nematoda
  - Nematode A
  - Nematode B
  - Nematode C
  - Nematode D
  - Nematode E
  - *Desmoscolex* sp.

- Phylum Kinorhyncha
  - *Echinoderes remanei*
  - *Semioderes* sp.
  - *Pycnophyes* sp.
  - *Trachydemus langi*

- Phylum Gastrotricha
  - Gastrotrich sp.

Table A6 (continued)

Phylum Phoronida
- *Phoronis architecta*

Phylum Mollusca
- Class Gastropoda
  - *Vitrinella* sp.
  - *Caecum glabrum*
- Class Bivalvia
  - *Abra aequalis*
  - *Tellina versicolor*
  - Disc-shaped bivalve
  - Unknown bivalve

Phylum Annelida
- Class Polychaeta
  - Cirratulidae sp.
  - *Jasminiera bilobata*
  - *Lumbrineris tenuis*
  - *Magelona* sp.
  - *Mediomastus californiensis*
  - *Pisione remota*
  - Polychaete D
  - Polychaete E
  - *Prionospio* spp.
  - *Sigambra* sp.
  - Spionidae sp.
  - Syllidae sp. A
  - Syllidae sp. B
  - Syllidae sp. C
- Class Archiannelida
  - *Nerillidae sp.*
  - *Polygordius appendiculatus*
  - Unidentified 3-segmented beast

Phylum Sipunculida
- *Aspidosiphon speciosus*
- *Golfingia* sp.
- Sipunculid sp. C

Phylum Arthropoda
Class Crustacea
- Subclass Copepoda
  - Order Harpacticoida
    - *Canuella canadensis*
    - *Ectinosoma* sp.
    - Ectinosomidae sp.

Table A6 (continued)

Phylum Arthropoda (continued)
        Harpacticidae sp.
        Copepodid stage
        Harpacticoid nauplius

      Order Cyclopoida
        Cyclopoid copepod

    Subclass Ostracoda
        Ostracod A
        Ostracod B
        Ostracod C
        Ostracod D

    Subclass Malacostraca
      Order Tanaidacea
        Leptochela rapax

      Order Amphipod
        Ampelisca abdita
        Other Ampeliscids
        Amphipod B

      Order Isopoda
        Anthuridae sp.
        Isopod B

      Order Cumacea
        Oxyurostylis salinoi
        Cumacea B

  Class Arachnida
      Order Acarina
        Acarina A
        Acarina B
        Acarina C
        Acarina D
        Acarina E
        Acarina F

  Class Pycnogonida
        Pycnogonida

Phylum Hemichordata
        Hemichordata sp.

Incertae sedis
        "Claw"
        "Hook-spined weird beast"

Table A7 Meiobenthic data, July 1976-April 1977: percent composition by taxon.

	Stations											
	1	2	3	4	5	6	7	8	9	10	11	12
Foraminifera	1.86	11.76	22.74	7.33	8.90	5.76	11.80	18.51	10.20	4.39	5.49	4.61
Cnidaria												
Nemertea	0.05									0.18	0.11	
Nematoda	86.17	80.09	59.28	79.93	65.07	46.76	79.31	50.46	57.32	69.60	70.18	65.46
Gastrotricha												
Kinorhyncha	0.76		1.14	1.16	0.86	0.18	0.06	1.03		0.44	0.34	0.40
Gastropoda	0.10			0.10	0.17	0.18		0.11		0.04		
Bivalvia	0.14		0.06	0.19	0.86			0.11	3.13	0.22		
Polychaeta	1.81	0.72	6.35	2.56	1.37	1.08	0.49	0.34	0.90	1.67	1.25	1.00
Archiannelida				0.05	0.17	15.83	0.19					
Phoronida				0.10	0.09					0.01		
Sipunculida	1.53	1.72	1.33	0.10	0.86	0.72	0.06	3.68	0.08	4.22	2.43	1.40
Harpacticoida	3.15	2.53	4.13	4.68	5.74	27.34	4.51	21.15	11.18	11.29	9.17	14.63
nauplii	1.76	2.62	4.57	0.82	9.16		3.40	2.64	1.81	4.61	6.17	7.88
Cyclopoida						0.36				0.04		
Ostracoda	1.18		0.06	2.75	5.65	0.72		1.95	12.42	3.08	5.72	3.34
Tanaidacea	0.10	0.09										0.13
Isopoda				0.10								0.27
Cumacea	0.10				0.09	0.90						
Amphipoda	0.38			0.05	0.09					0.09	0.28	0.73
Acarina	0.05	0.09	0.13	0.05	0.17		0.06			0.09	0.57	0.13
Pycnogonida	0.14		0.13		0.68	0.18						
Misc	0.10	0.36	0.06	0.05	0.09		0.12		2.96		0.34	

Table A7 (continued)

	Stations											
	13	14	17	18	21	26	32	34	35	36	39	40
Foraminifera	4.48	1.82	11.64	12.99	1.73	4.07	2.48	3.63	5.47	2.36	4.22	3.96
Cnidaria	0.06											
Nemertea						0.06					0.26	0.15
Nematoda	50.53	84.48	71.15	75.80	62.40	81.32	77.45	79.82	77.81	80.51	76.07	76.87
Gastrotricha												
Kinorhyncha	1.00	0.05	1.07	0.14	0.39	0.17	0.22	0.10	0.21		0.19	0.37
Gastropoda			0.57	0.07	0.13	0.06		0.20		0.06		
Bivalvia	0.66	0.31	0.16	0.29	0.74	0.06	0.22	2.12	1.16	3.57	1.60	0.22
Polychaeta	3.54	1.88	2.95	2.50	1.86	0.67	0.22	0.30	1.37	1.27	2.05	1.34
Archiannelida			0.16		1.04				0.11		0.19	
Phoronida												
Sipunculida	1.60	0.26	1.89	0.50	0.52	0.11	0.39	0.81	0.21	0.97	0.70	0.60
Harpacticoida	21.25	9.90	4.43	5.71	25.98	12.05	15.21	12.51	10.83	10.77	13.31	15.15
nauplii	11.23	0.05	3.03	1.71	4.77	0.95	2.98		1.05		0.45	0.97
Cyclopoida	0.06				0.13		0.11		0.21			
Ostracoda	5.37	0.89	1.31		0.13	0.17	0.72	0.20	0.95	0.36	0.70	0.22
Tanaidacea			0.16			0.06			0.63			
Isopoda					0.04	0.06						
Cumacea					0.09						0.06	
Amphipoda	0.17	0.36	0.08			0.17				0.06		
Acarina	0.06				0.04	0.06		0.30		0.06	0.19	
Pycnogonida			1.31	0.29								
Misc			0.08									0.15

Table A7 (continued)

	Stations										
	45	62	64	70	71	86	87	88	89	90	91
Foraminifera	4.23	3.28	5.76	4.26	3.44	4.01	1.82	3.06	3.70	3.87	5.52
Cnidaria											
Nemertea	0.10		0.07		0.05	0.06	0.15	0.12		0.18	0.36
Nematoda	72.15	73.45	63.32	59.50	74.39	75.92	83.13	70.14	73.24	80.54	77.19
Gastrotricha				0.13				0.12			
Kinorhyncha	0.10	0.11	0.94		0.11	0.13	0.30	0.24	0.15	0.09	0.60
Gastropoda					0.21					0.09	0.48
Bivalvia	2.75	0.29	0.40	0.13	0.11	0.13	0.15	0.54	0.83	0.65	0.24
Polychaeta	1.18	1.32	2.07	1.65	1.64	1.66	0.99	1.08	1.17	0.37	3.24
Archiannelida						0.06	0.23				
Phoronida										0.09	
Sipunculida	1.67	0.75	0.13	0.32	0.11	0.06	0.23	2.76	4.57	0.65	1.92
Harpacticoida	14.55	18.91	26.37	26.06	18.66	16.82	12.77	9.83	9.68	8.86	6.60
nauplii		1.03	0.47	7.25	1.27	0.64	0.15	9.77	4.28	2.86	3.24
Cyclopoida		0.11		0.06		0.19					
Ostracoda		0.06	0.33	0.19	0.27	0.13	0.08	1.26	0.78	0.46	0.12
Tanaidacea										0.18	
Isopoda				0.06					0.05	0.09	
Cumacea	0.10	0.11					0.15				
Amphipoda	0.10	0.34	0.07	0.25				1.02	0.49	0.28	0.12
Acarina	0.10	0.11	0.07	0.06	0.11	0.06	0.08	0.06	0.49	0.28	0.36
Pycnogonida						0.06					
Misc		0.11		0.06	0.16	0.06		0.06	0.58	0.46	

Table A7 (continued)

	Stations											
	92	93	94	95	96	97	98	104	105	106	107	108
Foraminifera	2.62	2.42	2.44	1.84	8.06	4.68	5.48	2.72	2.12	4.27	2.75	4.54
Cnidaria							0.05					
Nemertea			0.09	0.10	0.06		0.15	0.05	0.12	0.04	0.03	0.06
Nematoda	69.50	81.02	78.96	84.25	62.93	58.84	66.18	81.68	79.65	61.36	53.61	11.92
Gastrotricha												
Kinorhyncha	0.34	0.30	0.06	0.07	0.54	0.56	0.25	0.15	0.35	0.94	1.36	
Gastropoda		0.13			0.06	0.08		0.10		0.12	0.03	0.06
Bivalvia	0.72	0.08	0.12	0.14	2.39	4.92	0.05	0.05		2.46	0.87	0.18
Polychaeta	0.97	0.93	2.46	0.99	1.67	1.86	0.25	1.16	2.06	2.87	1.50	1.21
Archiannelida	0.08		0.03						0.06	0.70	0.94	0.18
Phoronida					0.12							
Sipunculida	0.13	0.08	1.73	0.54	1.55	2.26	0.20	0.50	0.12	1.39	0.07	0.06
Harpacticoida	18.78	10.04	8.39	8.10	13.49	10.25	22.01	12.68	14.51	16.69	26.07	15.49
nauplii	4.02	2.84	4.17	1.87	2.15	8.07	5.12		0.83	8.78	12.37	0.18
Cyclopoida		0.21										
Ostracoda	2.62	1.31	0.97	1.53	6.21	5.57		0.55	0.06	0.08	0.35	
Tanaidacea	0.04		0.03							0.04		
Isopoda					0.06	0.08		0.10				
Cumacea		0.08						0.05		0.04	0.03	0.06
Amphipoda		0.04	0.35	0.34	0.66	1.69		0.10	0.06	0.08		
Acarina		0.43	0.06		0.06	0.08	0.05	0.05		0.04		
Pycnogonida	0.08	0.04	0.12							0.04		
Misc	0.08	0.04	0.03	0.24		1.05	0.15	0.05	0.06	0.04		0.06

DEMERSAL FINFISH AND MACRO-CRUSTACEANS COLLECTED IN THE VICINITY OF BUCCANEER OIL FIELD DURING 1976-1977

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EXECUTIVE SUMMARY

Four cruises were conducted, on a quarterly schedule, to the Buccaneer Oil and Gas Field. Samples were taken in the platform and control areas with trawls, traps and longlines. Trawl sampling provided the bulk of the sampling data. A total of 47,530 specimens were processed (number per sample, lengths, weights), and 97 species of finfish and macrocrustaceans were identified.

Preliminary tests of data indicate differences between catches from the platform and control areas relating to the number of animals and number of species found in each. The platform area had the largest catch based on number per hour of all species combined (4,347 per hr), and the highest percent of total number of species (71%). Areas X and Y had catches in numbers per hour of 3,370 and 2,985 specimens, respectively.

The percent of total number of species followed the same pattern as did number of specimens per hour with area X having 68% and area Y, 64%. These differences are evident when plotted; however, we cannot say whether they are significant until final analyses are completed.

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INTRODUCTION

This report discusses demersal finfish and macro-crustaceans taken during four sampling cruises (summer, spring, fall and winter of 1976-1977). Samples were taken with trawls, traps, and by hook and line. From these samples a list of finfish and crustaceans was developed and is presented in this report. Also, data are included concerning relative abundance (by weight), distribution and length frequencies of six fish species and six species of crustaceans.

MATERIALS AND METHODS

Trawling

Trawl sampling was conducted at night from the Motor/Vessel GUS III. Areas X and Y (Figure 1) are located in open water and both areas were sampled with no difficulty. The oil field (area P) with its many jackets and two large platforms was more difficult to sample. A 12.2-m (40-ft) semiballoon shrimp trawl served as a bottom sampling gear. The trawl was pulled between the structures on as straight a course as possible. After losing part of a net, we did not attempt to trawl closer than 91.44 m (100 yd) of the structures. Weather and sea conditions determine how close to structures trawling can be conducted.

Cruise I, May 13-19, 1976

Trawl hauls on Cruise I were made with a 12.2-m (40-ft) semiballoon net with a cover enclosing the codend. The codend of the trawl is constructed of 3.2-cm (1-3/4-in) nylon mesh and the cover is 2.5-cm (1-in) nylon mesh

Each trawl haul was of a 20-min duration at a vessel speed of 2 to 2.5 knots. One night was devoted to trawling in each of the designated areas. The entire catch from the cover and net codend was emptied into separate wire baskets and weighed to get the total catch for each. If the total catch for the net codend was less than 9.072 kg (20 lb) the entire catch was put into cloth bags and frozen. For catches over this amount, a maximum 9.072 kg subsample was removed and frozen. Collections from the trawl cover were handled the same as the main trawl catch; however, the subsamples were 4.536 kg (10 lb) or less depending on the catch size.

Cruise II, August 9-11, 1976

There were two changes in trawl sampling for Cruise II. The net cover was removed and the towing time was extended to 1 hr.

Catches for Cruise II were processed in the same manner as those from Cruise I.

Cruise III, November 15-17, 1976 and Cruise IV, February 15-17, 1977

No procedural changes were made during Cruises III and IV. Samples were collected and processed exactly as those taken during Cruise II.

Traps

A modified version (Figure 2) of the sablefish trap (Hipkins, 1974) was tested during Cruise I and II in an attempt to collect species of fish and crustaceans not taken in trawl sampling. Baited traps were set for 1 night in each of the control areas and in the oil field area near the structures.

Cruise I

The first traps used had nylon mesh tunnels held open with rigid wire hoops. Excess fish from the trawl hauls were put into cloth bags, and one bag was suspended inside each cage to serve as bait. The traps were fished on the bottom for 4 hr. When this time expired, the traps were raised, the catch removed, the traps rebaited and lowered for another 4-hr set.

Cruise II

The tunnels in four of the traps were modified by removing the wire hoops and by stretching the nylon mesh to form horizontal slots. They were baited in the same manner as on the previous cruise. The traps were set on the bottom and allowed to fish for a period of 7-8 hr.

Cruise III and Cruise IV

Identical fishing procedures were followed as were used on Cruise II.

Bottom Hook and Line

Bottom longlines as well as handlines and snapper reels were tested on one cruise aboard the M/V GUS III and one cruise aboard the NOAA Research/Vessel KINGFISH.

Sample Processing at the Laboratory

Collections are removed from the freezers aboard the vessel and stored in a walk-in freezer unit at the laboratory. The latter unit keeps the samples frozen at -23.0° C. Individual 9.072-kg (20-lb) samples are removed from the freezer and allowed to thaw at room temperature. Species of finfish are identified to the lowest taxon using Galloway, et al. (1972), Topp and Ingle (1972), Breder (1948), Mead (unpublished MS), and Wood (1955). Voss (1955), Williams (1965), and Farfante (1969) are used for identification of macro-crustaceans.

Total weights and total numbers of individuals are recorded for each species. In addition, random samples of 25 specimens of each species are measured and weighed.

RESULTS

Trawl

The most productive sampling was done with the trawl. The combined samples from Cruise I through IV produced 75 species of finfish and 28 species of crustaceans (Table 1). Trawl samples from Cruise I contained 36 species of fish and 23 species of crustaceans. Samples from Cruise II contained 35 species of finfish and 15 species of crustaceans.

Species changes are evident (Table 2) between cruises. A total of 22 species of fish and 8 species of crustaceans occurred in first cruise samples that were not found in samples from the second cruise. Twenty-one species of fish were found in samples from Cruise II that were not found in Cruise I samples. Of the 57 species of fish collected, only 14 were found in the study areas during both sampling periods. Cruise III contained 10 finfish species and one macro-crustacean species that did not appear in Cruise II collections. Species changes between Cruises III and IV varied the least of all. Only 3 fish species and two macro-crustacean species were collected during Cruise IV that did not appear in Cruise III.

The subsample weights of each species were projected to total weights per tow. These data were used to compute the probability that the mean catch per tow was the same in the platform area (P) and the combined control areas (X and Y).

Length frequencies for four species of fish and four species of crustaceans from Cruise I and four species of fish and one crustacean from Cruise II are presented in Tables 3 and 4. Comparisons of length frequency data from the platform (P) and control (X and Y) areas show little or no difference for these species.

Traps - Hook and Line

Traps and bottom hook and line were used in the study area in an attempt to capture animals that were not caught with the trawl.

Sampling with the longline gear has not been successful to date. On the first attempt, weather conditions resulted in the loss of the longline. On the second attempt, two longlines were set, but rough sea conditions prevented our checking the lines for a 12-hr period. When the lines were retrieved, all of the baits were gone and numerous hooks were straightened or missing. The remains of a small shark that was still on one of the hooks would indicate that a school of large fish, probably sharks, had stripped the longlines of any catch.

Very few fish and invertebrates were caught with traps on the first cruise. Twenty-one trap samples produced a total of 30 animals (Table 5). Two of the fish, Caranx crysos and Haemulon macrostomum caught in the platform (P) area with the traps were not collected in trawl catches. The low catch of finfish may have been directly related to the round openings used in the tunnels of the traps. The fish possibly swam in and out of this type of opening. For this reason, tunnel openings were modified after Cruise I.

Eighteen samples were taken on Cruise II. The catch consisted of 48 crustaceans and 39 finfish (Table 5). Lutjanus campechanus dominated the catch for finfish and Callinectes spp. dominated the catch for crustaceans. The platform area produced one species of finfish (Equetus acuminatus) that had not been found in trawl samples. A total of 55 specimens representing six species of fish were collected on Cruise III with traps. Three species of crustaceans (seven specimens) were taken also. Eight traps were employed with a soak time of 6 hr. Twenty-six red snappers from area P dominated catches. Cruise IV collections contained 20 fish species representing four species. Sixteen were pigfish from area P. Only two species of crustaceans (three specimens) were caught. Eight traps were used with a soak time of 6 hr.

Trap sampling has resulted in the capture of four species of finfish that were not represented in the trawl catches.

Hydrographic observations recorded during Cruises I-IV are shown in Table 6.

Three species occurred in all four cruises and in all areas (around oil field structures and in both control areas): sugar shrimp (Trachypenaeus similis), brown shrimp (Penaeus aztecus) and bay whiff (Citharichthys spilopterus).

Figure 3 gives the mean average weight (kg) per individual. Brown shrimp occurred in greater densities during Cruise III (November) and sugar shrimp and bay whiff were more dense during Cruise I.

Figure 3 also shows mean catch (kg/hr) by species, and indicates large numbers of brown shrimp during Cruise II (August) and Cruise III (November). The bay whiff reaches its highest numbers during Cruise II (August)then declines in abundance. The sugar shrimp occurs in greatest numbers only during Cruise IV (February).

Comparisons of the two figures indicates that brown shrimp migrations reach their highest levels during the winter months. Sugar shrimp reach their highest densities in the winter months only. The bay whiff's highest densities occur in summer months.

An explanation of why these densities occur during the specific periods of each species previously mentioned can only be surmised to occur because of the migration patterns of the species discussed.

Whether or not the platforms concentrate these species cannot be determined due to insufficient data available for analysis at this time. More detailed analysis is now in progress.

A maze of pipelines (Figure 4) are intermingled between the well jackets and platforms. All lines lead to Platforms A and B where processing of gas and oil takes place. The product is transported to shore through a 20-in pipeline. Some difficulty was encountered in the trawling operation due to pipeline placement. To avoid crossing of the pipelines, an in and out towing pattern was employed.

The brown shrimp, *Penaeus aztecus*, sugar shrimp, *Trachypenaeus similis* and the bay whiff, *Citharichthys spilopterus* were the only species present in trawl catches during each of the quarterly cruises. Brown shrimp catch, as reflected by numbers caught per hour and total biomass per hour is presented in Figure 5. Catches from the study area adjacent to the platforms (area P) were about 100 per hour (2 kg/hr) compared to 60 per hour (1 kg/hr)in study area X and 27 per hour (½ kg/hr) in area Y. Concentrations of brown shrimp near the structures may be due to the shrimp's seeking refuge in an area protected from encroachment by shrimp vessels and trawls. Catches of sugar shrimp (Figure 6) surpassed all other species in both numbers caught (3,400/hr) and biomass caught (11 kg/hr) in area P. This species was almost twice as abundant in the platform area (P) as in areas Y and X. Bay whiff catches varied from those of brown shrimp and sugar shrimp (Figure 7). Greatest numbers of this species were taken in control area Y where 140 fish per hour were collected. A total of 125 specimens per hour were collected from area P with 48 per hour from area X.

LITERATURE CITED

Breder, C. M., Jr.
1948. Field Book of Marine Fishes of the Atlantic Coast. G. P. Putman's Sons.

Farfante, I. P.
1969. Western Atlantic shrimps of the Genus Penaeus U.S.D.I. Fishery Bulletin Vol. 67, No. 3, pp. 461-591.

Galloway, B. J. J. P. Parker and D. Moore.
1972. Key to the Estuarine and Marine Fishes of Texas. Tex. A&M Ext. Serv. Sec. Ed. TAMU-SG-402. pp. 1-177.

Hipkins, F. W.
1974. Collapsible rectangular sablefish trap. Fishery Facts, No. 7, pp. 1-10.

Mead, G. W.
(Unpublished MS) A preliminary list of the marine bony fishes known to occur in the Gulf of Mexico.

Topp, R. W. and R. M. Ingle.
1972. Annotated list of post 1950 literature pertaining to distribution of Gulf of Mexico fishes. Fla. Dept. Nat. Res. Mar. Res. Lab. SSR No. 33.

Voss, G. L.
1955. A key to the commercial and potentially commercial shrimp of the Family Penaeidae of the Western North Atlantic and the Gulf of Mexico. St. of Fla. Board of Conserv. Technical Series No. 14, pp. 1-22.

Williams, A. B.
1965. Marine decapod crustaceans of the Carolinas. U.S.D.I. Fishery Bulletin Vol. 65, No. 1, pp. 1-298.

Wood, C. E.
1974. Key to the Natantia (Crustacea, Decapoda) of the coastal waters on the Texas coast. Contrib. Mar. Sci., Vol. 18, pp. 35-56.

APPENDIX

Table 1. Common and scientific names of demersal finfish and macro-crustaceans from the Buccaneer Oil Field study area.

Common Name	Scientific Name
Demersal Finfish	
Blacknose shark	*Carcharhinus acronotus*
Blacktip shark	*Charcharhinus limbatus*
Atlantic sharpnose shark	*Rhizoprionodon terraenova*
Threadfin shad	*Dorosoma petenense*
Round herring	*Etrumeuis teres*
Atlantic thread herring	*Opisthonema oglinum*
Largescale lizardfish	*Saurida brasiliensis*
Inshore lizardfish	*Synodus foetens*
Sea catfish	*Arius felis*
Atlantic midshipman	*Porichthys porosissimus*
Pancake batfish	*Halieutichthys aculeatus*
Roughback batfish	*Ogcocephalus parvus*
Southern hake	*Urophycis floridanus*
Blackedge cusk-eel	*Lepophidium graellsi*
Rock seabass	*Centropristis philadelphica*
Dwarf sandperch	*Diplectrum bivittatum*
Pigmy seabass	*Searraniculus pumilio*
Belted sandfish	*Serranus subligarius*
Whitespotted soapfish	*Rypticus maculatus*
Greater soapfish	*Rypticus saponaceus*
Remora	*Remora remora*
Blue runner	*Caranx crysos*
Horse-eye jack	*Caranx latus*
Atlantic bumper	*Chloroscombrus chrysurus*
Rough scad	*Trachurus lathami*
Atlantic moonfish	*Vomer setapinnis*

Table 1. (Continued)

Common Name	Scientific Name
Red snapper	*Lutjanus campechanus*
Lane snapper	*Lutjanus synagris*
Tomtate	*Haemulon aurolineatum*
Spanish grunt	*Haemulon macrostomum*
Pigfish	*Orthopristis chrysoptera*
Pinfish	*Lagodon rhomboides*
Longspine porgy	*Stenotomus caprinus*
Sand seatrout	*Cynoscion arenarius*
Silver seatrout	*Cynoscion nothus*
High-hat	*Equetus acuminatus*
Banded drum	*Larimus fasciatus*
Spot	*Leiostomus xanthurus*
Southern kingfish	*Menticirrhus americanus*
Atlantic croaker	*Micropogon undulatus*
Dwarf goatfish	*Upeneus parvus*
Atlantic threadfin	*Polydactylus octonemus*
Atlantic cutlassfish	*Trichiurus lepturus*
Gulf butterfish	*Peprilus burti*
Smoothhead scorpionfish	*Scorpaena calcarata*
Blackfin searobin	*Prionotus rubio*
Bandtail searobin	*Prionotus ophryas*
Blackwing searobin	*Prionotus salmonicolor*
Ocellated flounder	*Ancylopsetta quadrocellata*
Bay whiff	*Citharichthys spilopterus*
Fringed flounder	*Etropus crossotus*
Smallmouth flounder	*Etropus microstomus*
Gulf flounder	*Paralichthys albigutta*

Table 1. (Continued)

Common Name	Scientific Name
Dusky flounder	Syacium papillosum
Offshore tonguefish	Symphurus civitatus
Spottedfin tonguefish	Symphurus diomedianus
Blackcheek tonguefish	Symphurus plagiusa
Planehead filefish	Monacanthus hispidus
Gray triggerfish	Balistes capriscus
Scrawled cowfish	Lactophrys quadricornis
Smooth puffer	Lagocephalus laevigatus
Least puffer	Sphoeroides parvus
Bandtail puffer	Sphoeroides spengleri
Roundel skate	Reja texana
Southern stingray	Dasyatis americana
Palespotted eel	Ophichthus ocellatus
Scaled sardine	Harengula pensacolae
Leopard toadfish	Opsanus pardus
Crested cusk-eel	Phidion welshi
Striped cusk-eel	Rissola marginata
Rough silverside	Membras martinica
Silver jenny	Eucinostomus gula
Mottled mojarra	Eucinostomus lefroyi
Cubbyu	Equetus umbrosus
Black drum	Pogonias cromis
Red drum	Sciaenops ocellata
Atlantic spadefish	Chaetodipterus faber
Horned searobin	Bellator militaris
Mexican flounder	Cyclopsetta chittendeni
Fringed sole	Gymnachirus texae
Striped burrfish	Chilomycterus schoepfi

Table 1. (Continued)

Common Name	Scientific Name
	Macro-crustaceans
Brown shrimp	*Penaeus aztecus*
White shrimp	*Penaeus setiferus*
Pink shrimp	*Penaeus duorarum*
Sugar shrimp	*Trachypenaeus similis*
Rock shrimp	*Sicyonia brevirostris*
Chevron shrimp	*Sicyonia dorsalis*
Brokenback shrimp	*Solenocera vioscai*
Gulf crab	*Callinectes danae*
Blue crab (small)	*Callinectes ornatus*
Swimming crab	*Callinectes sapidus*
Swimming crab	*Portunus anceps*
Swimming crab	*Portunus gibbesii*
Swimming crab	*Portunus spinimanus*
Box crab	*Calappa sulcata*
Calico crab	*Hepatus epheliticus*
Porcelain crab	*Porcellana sayana*
Lady crab	*Ovalipes ocellatus guadulpensis*
Speckled crab	*Arenaeus cribrarius*
Red hermit crab	*Petrochirus bahamensis*
Spider crab	*Libinia emarginata*
Spider crab	*Parthenope serrata*
Spider crab	*Parthenope pourtalesii*
Purse crab	*Persephona punctata aquilonaris*
Purse crab	*Persephona crinata*
Purse crab	*Myropsis quinquespinosa*
Arrow crab	*Metoporhaphis calcarata*
Red crab	*Loligo pealei*

Table 1. (Continued)

Common Name	Scientific Name
White crab	*Lolliguncula brevis*
Mantis shrimp	*Squilla empusa*
Mantis shrimp	*Squilla neglecta*
Crab	*Calappa angusta*

Table 2. Distribution of trawl caught finfish and macro-crustaceans, all cruises.

Scientific Name	Cruise I			Cruise II			Cruise III			Cruise IV		
	Area			Area			Area			Area		
	Y	P	X	Y	P	X	Y	P	X	Y	P	X
FINFISHES												
Carcharhinus limbatus					X							
Dorosoma petenense						X						
Etrumeus teres						X						
Opisthonema oglinum						X						
Saurida brasiliensis	X	X	X					X			X	
Arius felis			X	X	X	X	X	X	X	X	X	X
Porichthys porosissimus	X	X	X	X		X	X	X	X			
Halieutichthys aculeatus	X	X	X				X	X	X	X	X	X
Ogcocephalus parvus	X	X	X		X		X	X	X	X	X	X
Urophycis floridanus	X	X	X							X	X	X
Lepophidium graellsi	X	X	X	X			X	X	X			X
Centropristis Philadelphica	X						X	X	X	X	X	
Diplectrum bivittatum	X	X	X	X	X	X	X	X	X	X	X	X
Serraniculus pumilio		X										
Serranus subligarius			X									
Rypticus maculatus[1/]			X									
Rypticus saponaceus[1/]			X									
Caranx latus						X						
Chloroscombrus chrysurus					X			X				
Trachurus lathami		X		X	X	X						
Vomer setapinnis					X							
Lutjanus campechanus	X	X	X	X	X	X	X	X	X	X	X	
Lutjanus synagris	X											
Haemulon aurolineatum					X			X				
Haemulon macrostomum		X										
Orthopristis chrysoptera			X				X	X	X	X	X	

Table 2. (Continued)

Scientific Name	Cruise I			Cruise II			Cruise III			Cruise IV		
	Area			Area			Area			Area		
	Y	P	X	Y	P	X	Y	P	X	Y	P	X
Lagodon rhomboides		X	X		X	X	X	X	X	X	X	
Stenotomus caprinus	X	X	X	X	X	X						
Cynoscion arenarius				X	X			X	X			
Cynoscion nothus				X	X	X						
Larimus fasciatus				X		X			X			
Leiostomus xanthurus		X		X	X	X	X	X	X			
Menticirrhus americanus				X		X						X
Micropogon undulatus				X	X	X	X	X	X		X	X
Upeneus parvus	X	X										
Polydactylus octonemus				X	X	X	X		X			
Trichiurus lepturus					X	X						
Peprilus burti					X	X					X	X
Scorpaena calcarata	X	X	X				X	X	X	X	X	
Prionotus rubio	X	X	X	X	X	X	X	X	X	X	X	
Prionotus ophryas					X		X	X	X			
Prionotus salmonicolor		X						X			X	
Ancylopsetta quadrocellata		X										
Citharichthys spilopterus	X	X	X	X	X	X	X	X	X	X	X	X
Etropus crossotus	X	X						X				
Etropus microstomus				X	X		X		X	X	X	X
Paralichthys albigutta		X					X	X				X
Syacium papillosum	X			X					X		X	
Symphurus civitatus		X					X					
Symphurus diomedianus	X											
Symphurus plagiusa	X	X	X						X	X	X	
Monacanthus hispidus				X		X						

Table 2. (Continued)

Scientific Name	Cruise I			Cruise II			Cruise III			Cruise IV		
	Area			Area			Area			Area		
	Y	P	X	Y	P	X	Y	P	X	Y	P	X
Balistes capriscus					X			X				
Lactophrys quadricornis	X		X						X			
Lagocephalus laevigatus				X								
Sphoreoides parvus	X	X	X	X	X	X	X	X	X		X	
Sphoeroides spengleri	X	X										
Harengula pensacola					X							
Raja texana							X	X			X	
Dasyatis americana								X				X
Ophidion welshi									X			
Rissola marginata									X			
Membras martinica								X				
Eucinostomus gula								X	X			
Pogonias cromis											X	X
Sciaenops ocellata										X		
Chaetodipterus faber									X			
Cyclopsetta chittendeni							X	X	X			
Chilomycterus schoepfi									X			X
Synodus foetens							X	X	X	X		
MACRO-CRUSTACEANS												
Penaeus aztecus		X	X	X	X	X	X	X	X	X	X	X
Penaeus setiferus												X
Penaeus duorarum	X	X	X	X	X	X	X	X	X	X	X	X
Trachypenaeus similis	X	X	X		X	X	X	X	X	X	X	X
Solenocera vioscai		X					X	X	X	X	X	X
Sicyonia brevirostris	X	X	X			X	X	X	X	X	X	X
Sicyonia dorsalis	X	X	X	X	X		X	X	X	X	X	X
Callinextes danae	X	X		X	X	X	X		X			X
Callinectes ornatus		X		X								
Callinectes sapidus	X	X	X		X							

Table 2. (Continued)

Scientific Name	Cruise I			Cruise II			Cruise III			Cruise IV		
	Area			Area			Area			Area		
	Y	P	X	Y	P	X	Y	P	X	Y	P	X
Portunus anceps	X	X	X	X			X	X	X	X	X	X
Portunus gibbesii	X	X	X	X	X	X	X	X	X	X	X	X
Portunus spinimanus	X	X	X									
Calappa angusta	X	X	X									
Calappa sulcata	X			X	X		X					
Hepatus epheliticus	X	X	X				X					
Porcellana sayana	X				X							
Libinia emarginata		X				X				X		X
Parthenope serrata	X											
Parthenope pourtalesii		X										
Persephona punctata aquilonaris		X										
Persephona crinata	X											
Myrophis ponetatus			X									
Loligo pealei	X			X	X	X	X	X		X	X	X
Lolliguncula brevis		X	X				X	X	X	X	X	X
Squilla empusa	X	X	X	X	X	X	X	X	X	X	X	X
Squilla neglecta		X					X					X

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[1] Possibly one species only.

Table 3. Relevant statistics for 24, 20-min. tows made during May 1976 (Cruise I) with a 12.2 m. semiballoon trawl to compare the platform area with the control areas.

Scientific Name	Mean weight (kg) caught/standard tow		Calculated Students T-Statistic	Probability Level[1/]
	Area X & Y	Area P		
		Finfish		
Saurida brasiliensis	.0220	.0031	1.81	.08
Arius felis	.1260	0.0	1.70	.10
Porichthys porosissimus	.0231	.1074	-1.84	.08
Halieutichthys aculeatus	.0172	.0253	-0.79	.44
Ogcocephalus parvus	.4125	.2075	1.41	.17
Urophycis floridanus	.0125	.0158	-0.27	.79
Lepophidium graellsi	.0804	.1358	-1.02	.32
Centropristis philadelphica	.0046	0.0	1.19	.25
Diplectrum bivittatum	1.7925	1.6250	0.44	.66
Serraniculus pumilio	0.0	.0007	-0.84	.41
Serranus subligarius	.0021	0.0	1.19	.25
Rypticus maculatus	.0198	0.0	1.25	.22
Trachurus lathami	0.0	.0009	-0.84	.41
Lutjanus campechanus	.5563	.9764	-0.54	.59
Lutjanus synagris	0.0	.0044	+1.19	.25
Orthopristis chrysoptera	.0539	0.0	+1.19	.25
Lagodon rhomboides	.0193	.0193	-0.00	1.0
Stenotomus caprinus	.3428	.1610	2.02	.06
Leiostomus xanthurus	0.0	.0132	-1.23	.23
Upeneus parvus	.0004	.0004	-0.00	1.0
Scorpaena calcarata	.0084	.0448	-1.93	.07
Prionotus rubio	.0045	.0173	-1.33	.20
Prionotus salmonicolor	0.0	.0011	-0.84	.41
Ancylopsetta quadrocellata	0.0	.0111	-1.45	.16
Citharichthys spilopterus	.1852	.6468	-2.62	.02
Etropus crossotus	.0979	.0115	1.61	.12
Paralichthys albigutta	0.0	.0158	-0.84	.41
Syacium papillosum	.1154	.0576	.54	.59

Table 3. (Continued)

Scientific Name	Mean weight (kg) caught/standard tow		Calculated Students T-Statistic	Probability Level[1/]
	Area X & Y	Area P		
Symphurus civitatus	0.0	.0283	-2.34	.03
Symphurus diomedianus	.0029	.0021	0.26	.80
Symphurus plagiusa	.0257	.0177	0.60	.55
Lactophrys quardricornis	.0988	0.0	1.54	.14
Sphoeroides parvus	.0538	.0165	1.56	.13
Sphoeroides spengleri	.0080	.0037	0.81	.43
		Macro-crustaceans		
Penaeus aztecus	.0050	.0079	-0.52	.61
Penaeus setiferus	0.0	.0083	-0.84	.41
Penaeus duorarum	.4173	.4716	-0.28	.78
Trachypenaeus similis	8.1284	6.5982	0.47	.64
Sicyonia brevirostris	.1978	.4493	-2.83	.0[illegible]
Sicyonia dorsalis	.1875	.1145	1.25	.22
Callinectes danae	.0010	.0169	-0.58	.57
Callinectes ornatus	0.0	.0092	-0.84	.41
Callinectes sapidus	.2467	.1025	1.68	.11
Portunus anceps	.0077	.0114	-0.44	.66
Portunus gibbesii	.0381	.0213	0.75	.46
Portunus spinimanus	.0275	.0497	-0.69	.50
Calappa sulcata	0.0	.0831	-1.43	.17
Hepatus epheliticus	.0161	.0265	-0.66	.52
Porcellana sayana	.0003	0.0	1.19	.25
Petrochirus bahamensis	.0045	0.0	1.19	.25
Libinia emarginata	0.0	.0503	-0.84	.41
Parthenope serrata	.0004	0.0	1.19	.25
Parthenope pourtalesii	0.0	.0002	-0.84	.41
Persephona punctata aquilonaris	.0004	.0026	-1.47	.16

Table 3. (Continued)

Scientific Name	Mean weight (kg) caught/standard tow		Calculated Students T-Statistic	Probability Level[1]
	Area X & Y	Area P		
Persephona crinata	.0004	0.0	1.19	.25
Metoporhaphis calcarata	.0455	.00005	1.19	.25
Loligo pealei	0.0	.0027	-0.84	.41
Lolliguncula brevis	.0402	.0774	-1.05	.31
Squilla empusa	.1015	.1321	-0.72	.48
Squilla neglecta	0.0	.0025	-0.84	.41
Calappa angusta	.0282	.0052	2.03	.05

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[1] Probability that the mean C/T was the same in the two areas.

Table 4. Relevant statistics for 10, 1-hr tows made during August 1976 (Cruise II) with a 12.2-m. semiballoon trawl to compare the platform area with the control areas.

Scientific Name	Mean weight (kg) caught/standard tow		Calculated Students T-Statistic	Probability Level[1/]
	Area X & Y	Area P		
		Finfish		
Carcharhinus limbatus	0.0	.5588	-1.26	.24
Porosoma petenense	.0994	0.0	+0.80	.45
Etrumeus teres	.3126	0.0	+0.80	.45
Opisthonema oglinum	.6003	0.0	+0.80	.45
Arius felis	.7076	1.0513	-0.58	.58
Porichthys porosissimus	.1408	0.0	1.56	.16
Ogcocephalus parvus	0.0	.1976	-1.32	.22
Lepophidium graellsi	.0217	0.0	.80	.45
Diplectrum bivittatum	.5476	2.4492	-2.41	.04
Caranx latus	.1574	0.0	.80	.45
Chloroscombrus chrysurus	0.0	.1548	-2.47	.04
Trachurus lathami	.2066	.8299	-0.93	.38
Vomer setapinnis	0.0	.0862	-1.26	.24
Lutjanus campechanus	.6779	.3091	.77	.46
Haemulon aurolineatum	0.0	.0004	-1.26	.24
Lagodon rhomboides	.1359	.0809	.30	.77
Stenotomus caprinus	16.4520	5.3180	2.04	.08
Cynoscion arenarius	.6648	.4163	.28	.79
Cynoscion nothus	5.6928	1.9175	.76	.47
Larimus fasciatus	.2985	0.0	1.22	.26
Leiostomus xanthurus	4.6053	.4573	1.82	.11
Menticirrhus americanus	.8269	.3010	.64	.54
Micropogon undulatus	70.8012	7.2897	1.77	.11
Polydactylus octonemus	2.9558	1.9676	.80	.45
Trichiurus lepturus	.2481	.4637	-0.57	.58
Peprilus burti	5.0188	.2411	1.15	.28
Scorpaena calcarata	0.0	.2629	-1.26	.24
Prionotus rubio	.4907	.3696	.35	.74

Table 4. (Continued)

Scientific Name	Mean weight (kg) caught/standard tow		Calculated Students T-Statistic	Probability Level[1]
	Area X & Y	Area P		
Prionotus ophryas	0.0	.0300	-1.26	.24
Citharichthys spilopterus	.6435	1.0667	-0.85	.42
Etropus microstomus	.08597	.0215	.59	.57
Syacium papillosum	.1108	0.0	.80	.45
Monacanthus hispidus	.2796	0.0	1.00	.35
Balistes capriscus	0.0	.0172	-1.26	.24
Lagocephalus laevigatus	.1429	.2030	-0.25	.81
Sphoeroides parvus	.0318	.0604	-0.90	.39
Harengula pensacola	0.0	.2116	-1.25	.24
		Macro-crustaceans		
Penaeus aztecus	2.9298	8.3017	-1.75	.12
Penaeus duorarum	.2488	.5100	-0.96	.37
Trachypenaeus similis	.0174	.0688	-0.88	.40
Sicyonia brevirostris	.0279	0.0	.80	.45
Sicyonia dorsalis	.02160	.0363	-0.62	.55
Callinectes danae	.6883	.2018	.90	.39
Callinectes ornatus	.1257	0.0	.80	.45
Callinectes sapidus	0.0	.3790	-1.27	.24
Portunus anceps	.0065	0.0	.80	.45
Portunus gibbesii	.0208	.1960	-1.32	.22
Calappa sulcata	.1174	.2451	-0.53	.61
Porcellana sayana	0.0	.0002	-1.26	.24
Libinia emarginata	1.4237	0.0	.80	.45
Loligo pealei	.6934	2.5414	-1.88	.10
Squilla empusa	.0666	.2255	-1.64	.14

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[1] Probability that the mean C/T was the same in the two areas.

Table 5. Demersal fish and crustaceans collected by traps.

Scientific Name	Cruise I			Cruise II			Cruise III			Cruise IV		
	Area			Area			Area			Area		
	Y	P	X	Y	P	X	Y	P	X	Y	P	X
FINFISH												
Arius felis			X			X		X	X			
Rypticus maculatus					X							
Caranx crysos		X										
Lutjanus campechanus	X			X	X	X	X	X				
Haemulon aurolineatum					X							
Haemulon macrostomum		X										
Orthopristis chrysoptera							X		X		X	
Lagodon rhomboides									X			
Equetus acuminatus					X							
Micropogon undulatus									X			
Equetus umbrosus								X				
Chaetodipterus faber											X	
Ophichthus ocellatus												X
Opsanus pardus											X	
CRUSTACEANS												
Callinectes danae	X			X		X			X			
Callinectes sapidus		X	X	X		X			X		X	
Portunus anceps	X											
Portunus gibbesii	X		X									
Portunus spinimanus	X	X	X						X			
Hepatus epheliticus		X										
Porcellana sayana	X			X								
Libinia emarginata	X			X			X		X			X
Metoporhaphis calcarata		X										

Table 6. Observations of oxygen, Temperature, and salinity, Buccaneer Oil Field, 1976-77.

Hydrography	Cruise I (May)			Cruise II (August)			Cruise III (November)			Cruise IV (February)		
	Area			Area			Area			Area		
	Y	P	X	Y	P	X	Y	P	X	Y	P	X
Oxygen (ml/l)												
Surface	5.07	4.96	5.00	4.94	4.57	4.57	7.3	6.1	7.8	7.6	7.8	7.2
Midwater	2.69	4.95	5.15	4.59	5.09	5.03	7.5	6.8	8.2	7.8	7.4	7.4
Bottom	4.78	4.92	4.81	5.30	4.82	4.66	7.5	7.0	8.3	7.8	7.2	7.2
Temperature (^{o}C)												
Surface	24.25	24.0	22.0	29.5	29.0	29.0	16.8	16.5	17.0	15.0	13.5	12.5
Midwater	23.00	24.0	23.5	28.9	29.0	28.5	16.0	15.0	16.0	15.5	14.0	12.5
Bottom	22.55	23.0	23.0	27.5	28.0	28.5	16.0	15.0	16.0	14.5	13.5	12.0
Salinity (^{o}/oo)												
Surface	32.15	25.0	29.10	32.1	32.1	32.1	35.4	32.8	35.2	35.0	35.0	34.0
Midwater	29.45	26.5	25.10	32.1	32.1	32.8	35.4	35.8	35.2	35.5	35.0	34.0
Bottom	32.50	31.0	30.00	33.6	33.6	--	35.4	35.8	35.4	35.	35.0	36.0

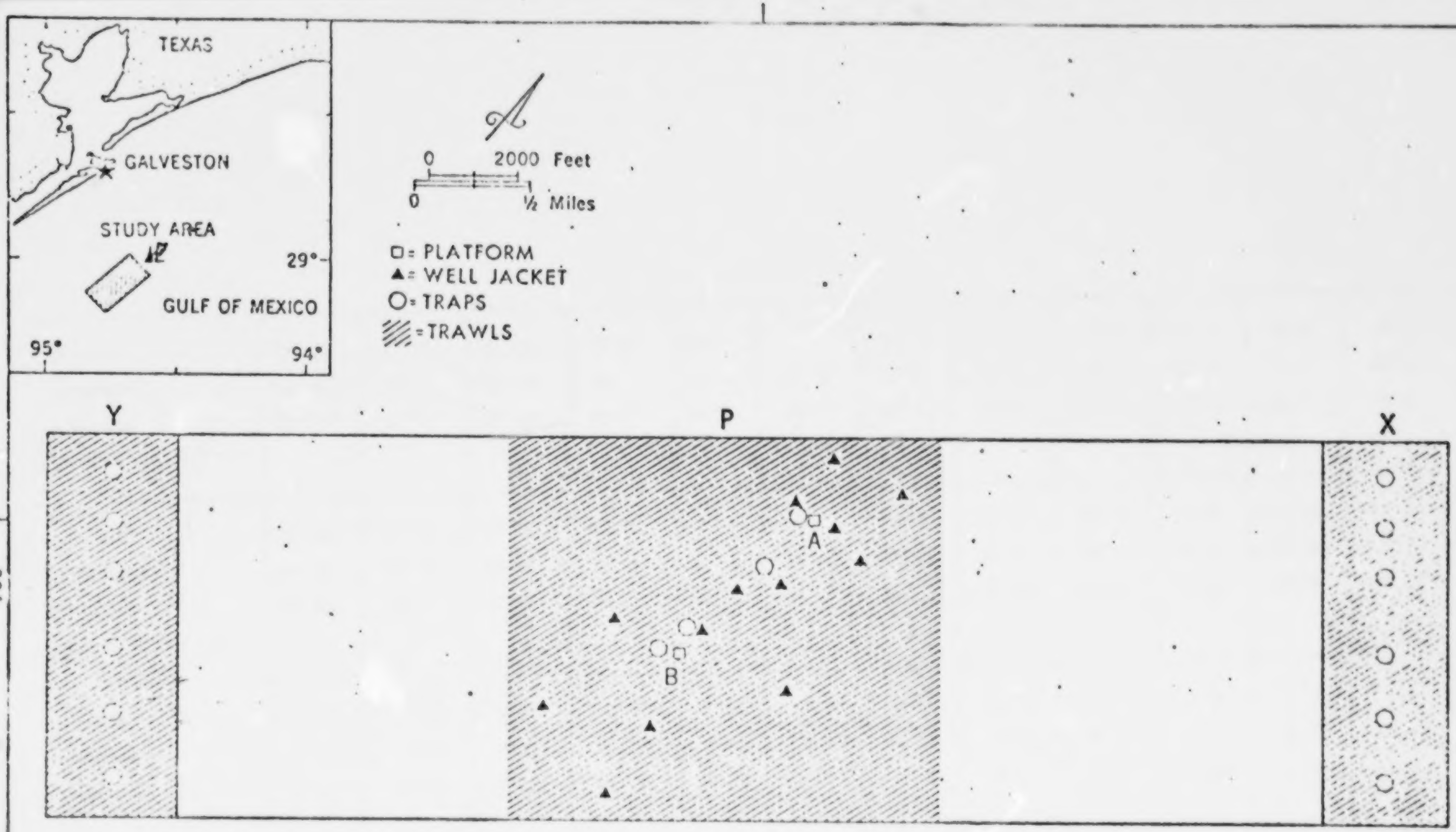
TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0
2000 Feet
0
½ Miles
□= PLATFORM
▲= WELL JACKET
○= TRAPS
▨=TRAWLS
Y
P
X
A
B

Figure 1. Location of areas where samples were taken

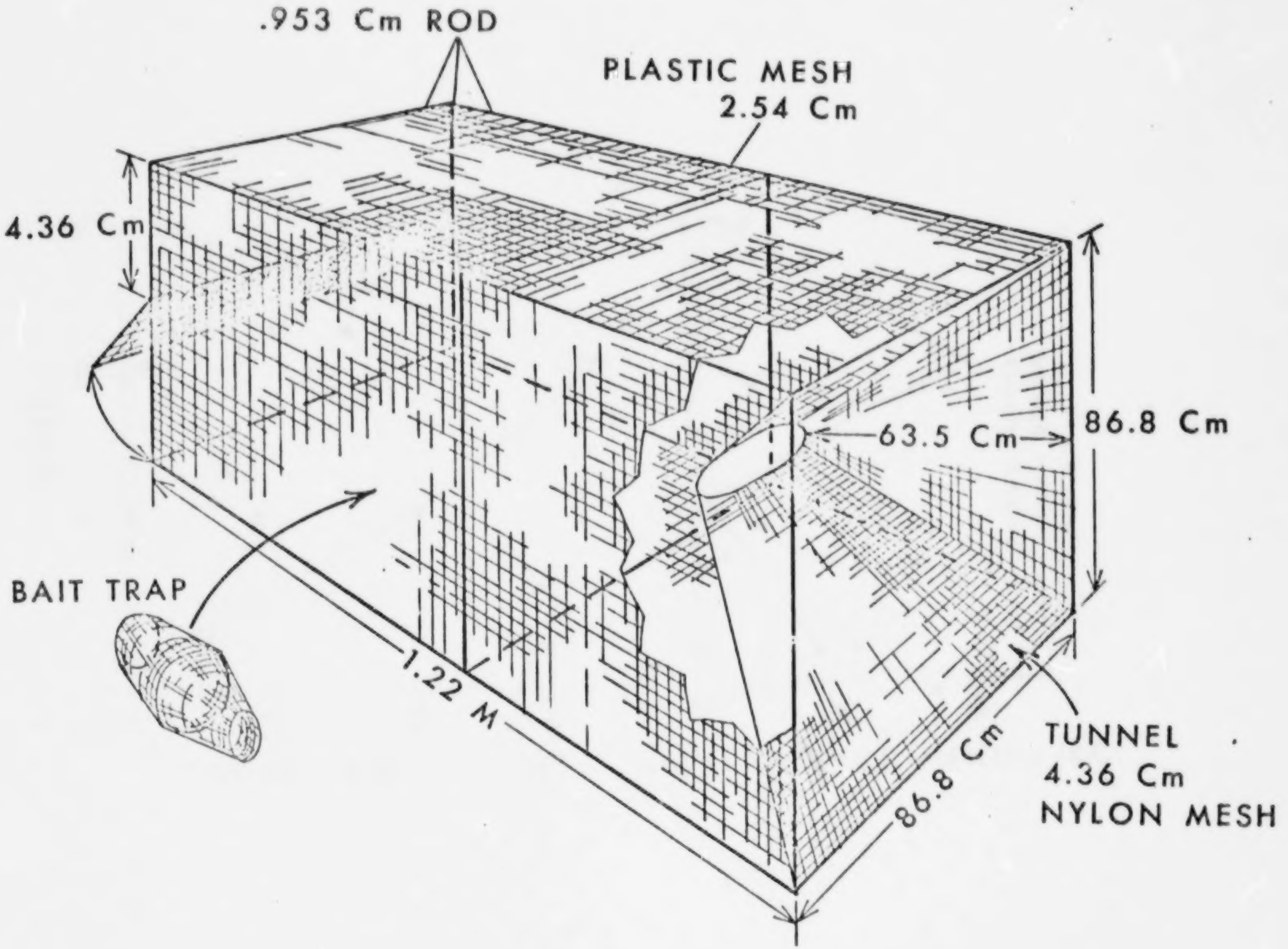
.953 Cm ROD
PLASTIC MESH
2.54 Cm
4.36 Cm
86.8 Cm
63.5 Cm
BAIT TRAP
1.22 M
86.8 Cm
TUNNEL
4.36 Cm
NYLON MESH

Figure 2. Modified sablefish trap

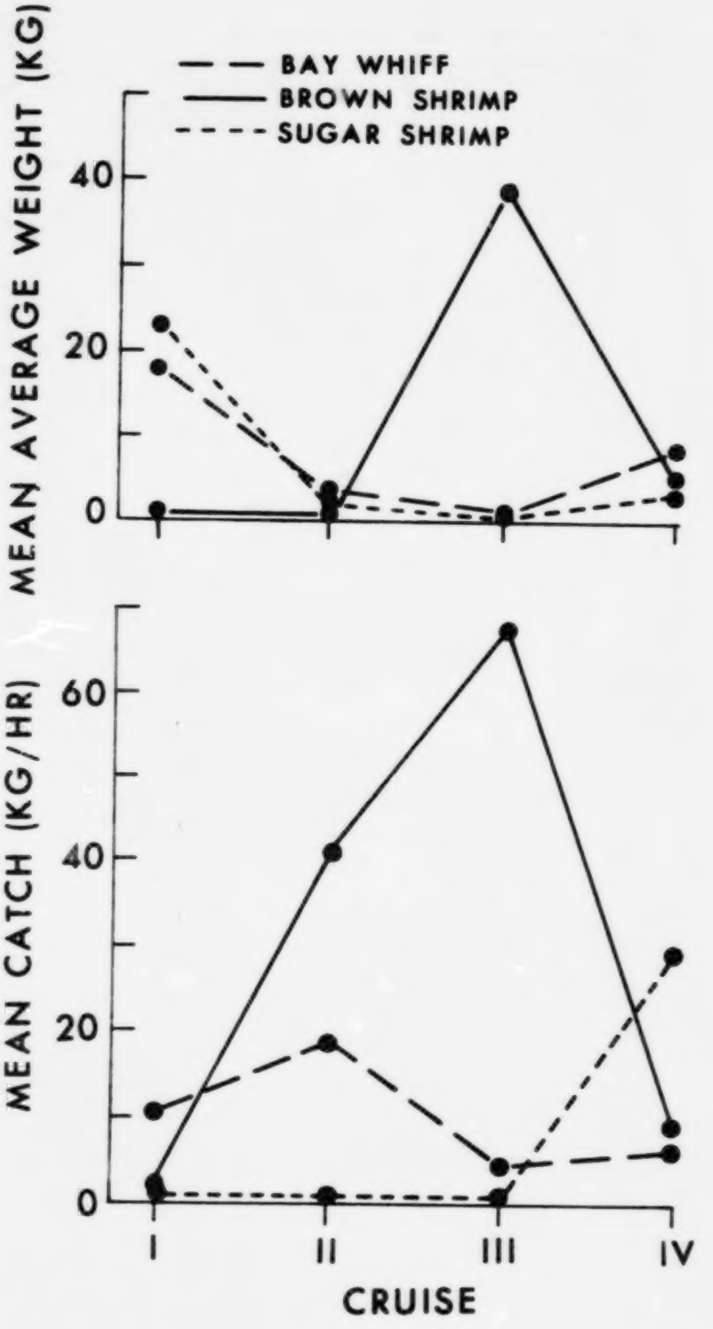

Figure 3. Distribution of three species that occur in all cruises within the oil field.

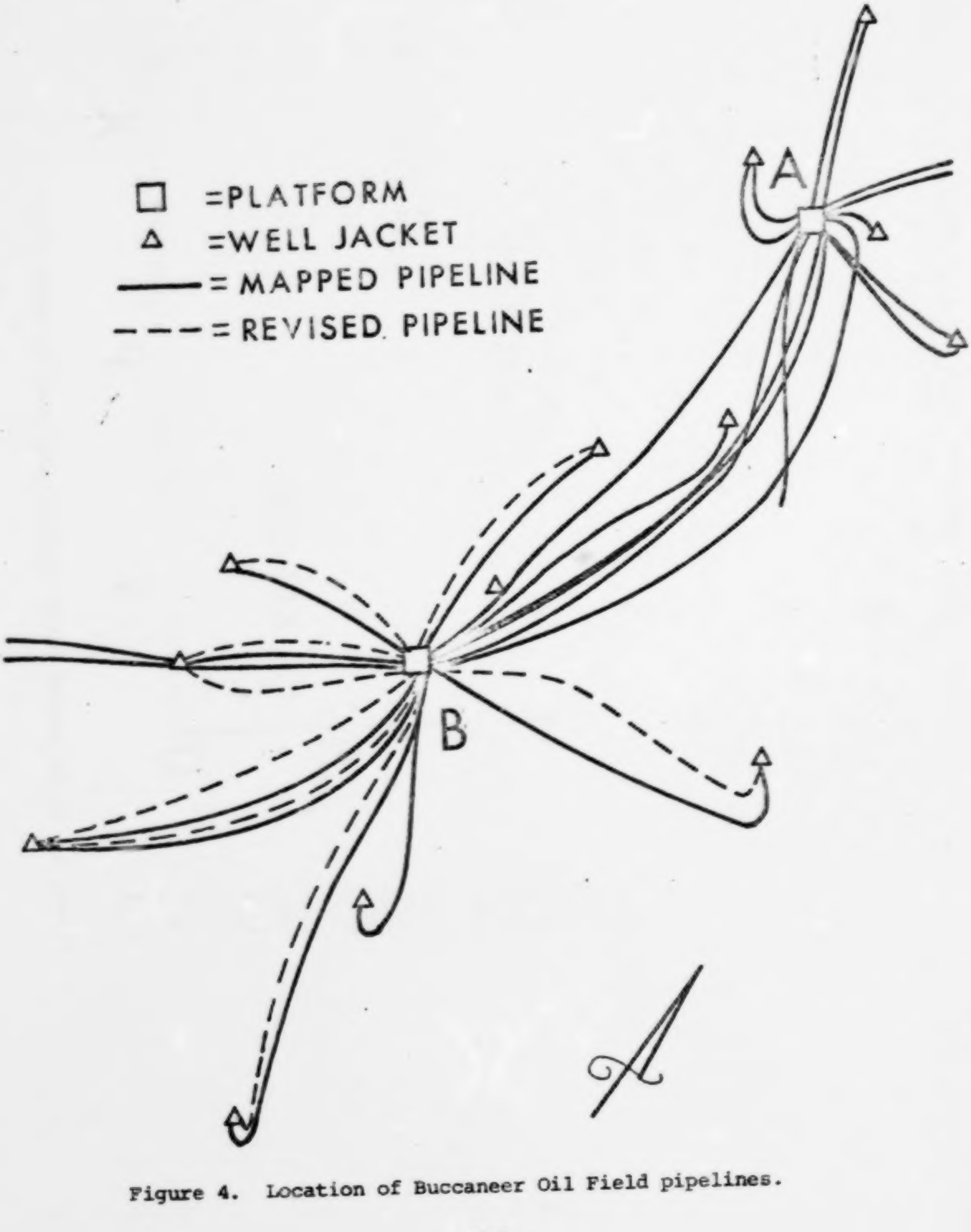
□ =PLATFORM
△ =WELL JACKET
——— = MAPPED PIPELINE
– – – = REVISED PIPELINE
A
B

Figure 4. Location of Buccaneer Oil Field pipelines.

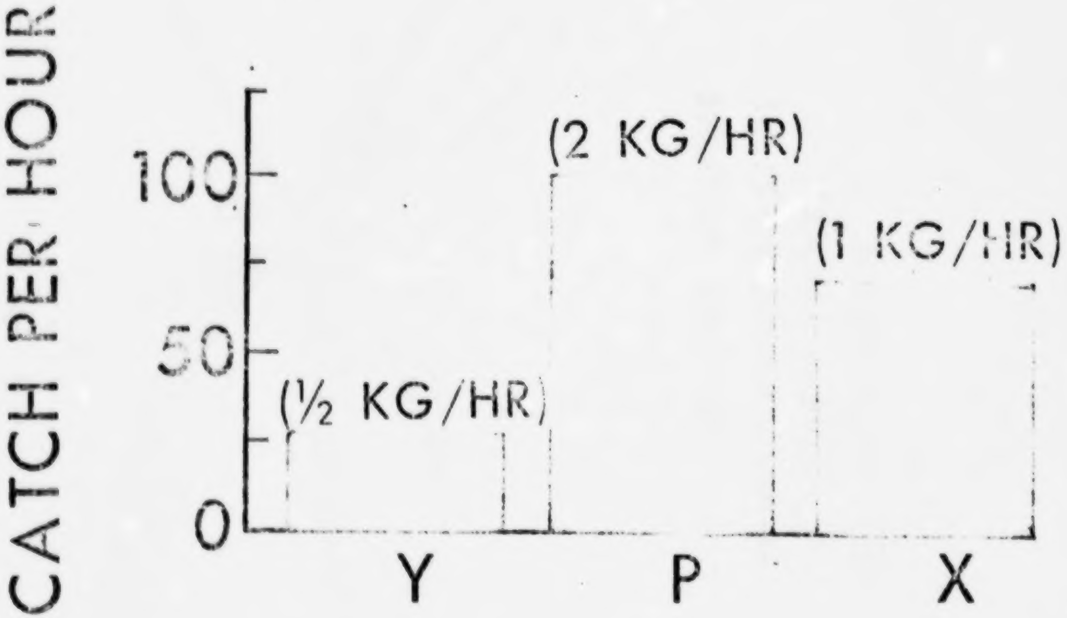

Figure 5. Brown shrimp catch (number) per hour by study areas.

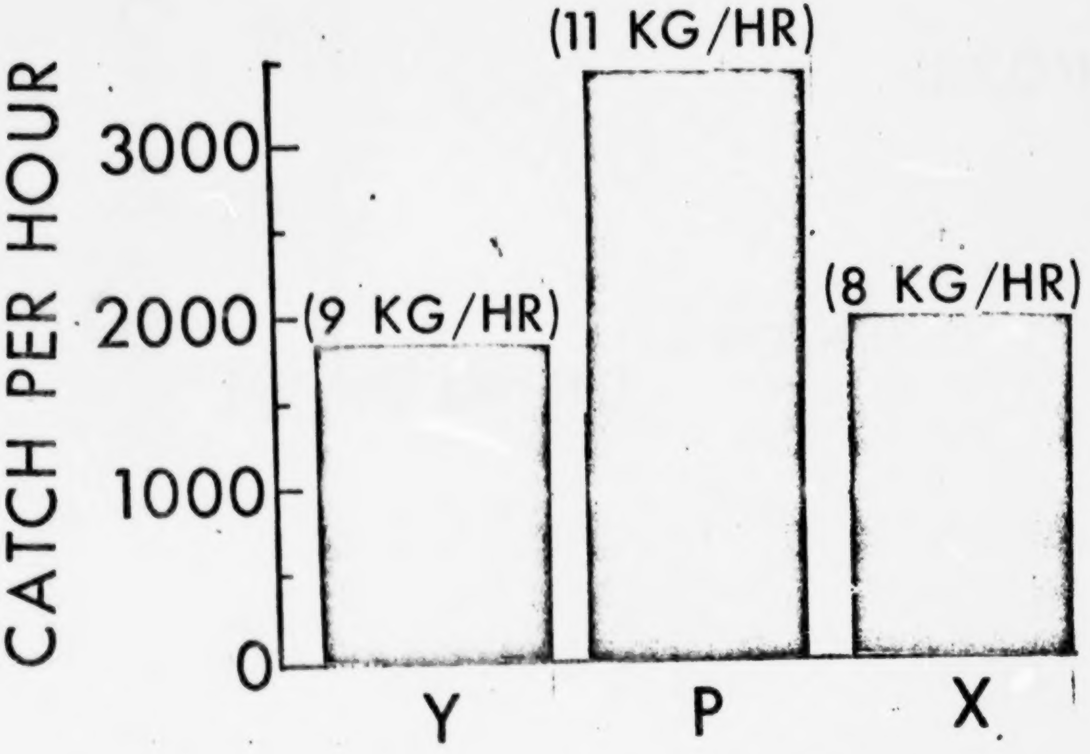

Figure 6. Sugar shrimp catch (number) per hour by study areas

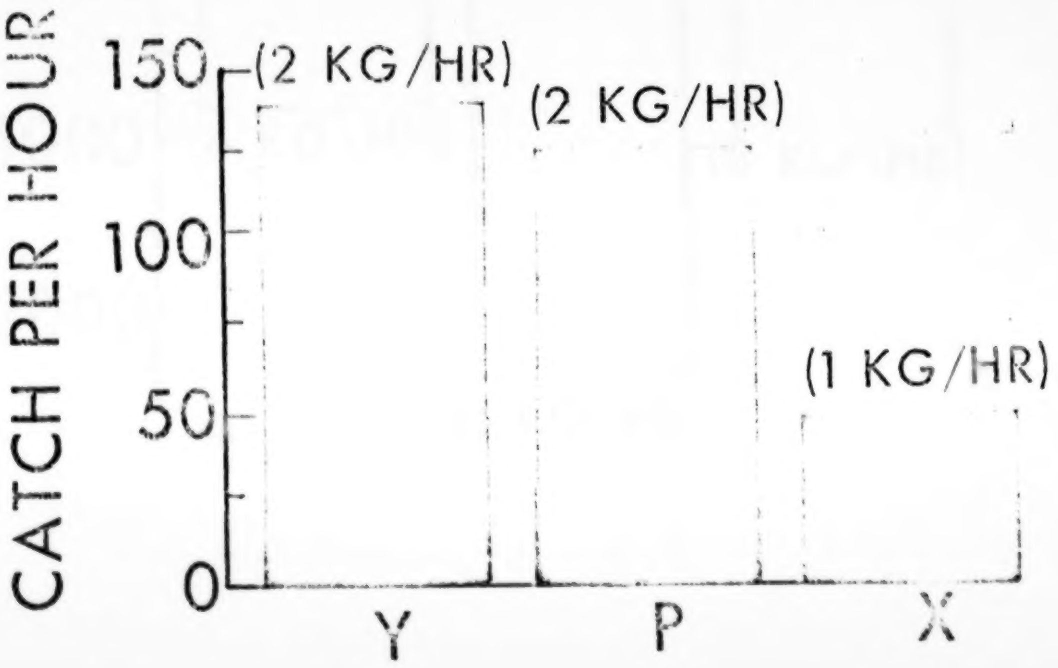

Figure 7. Bay whiff catch (number) per hour by study areas

RECREATIONAL FISHERIES AND THE DISTRIBUTION OF PREDATORY PELAGIC FISHES

Principal Investigator

Lee Trent

Associate Investigators

Ian K. Workman
Steve Dime
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EXECUTIVE SUMMARY

Recreational fishing effort in the Buccaneer Oil Field varied greatly between days; the mean instantaneous number of boats counted in the area ranged from 0.0 to 25.0 on different sampling days and averaged 2.85 boats on weekdays and 10.8 boats on weekend days. The highest amount of fishing effort occurred in late August and September. The percents of boats participating in each type of recreational fishing activity were: bottom fishing, 77%; trolling, 17%; and diving, 6%. All of the diving effort and 98% of the bottomfishing and trolling effort occurred in the inner zone of the study area. About 78% of the boats observed were in the 6.6- to 9.8-m (20- to 30-ft) length class and were most abundant in the study area around mid-day.

During the survey, 22 species were caught by recreational fishermen in the study area and identified by our field personnel. Six species or less represented over 90% of the total number of fish caught in each type of fishing activity. The 10 most abundantly caught species were red snapper, king mackerel, dolphin, Atlantic spadefish, blue fish, pigfish, Spanish mackerel, sheepshead, bull shark, and blue runner. The mean numbers of fish (species combined) caught per fisherman hour in relation to activity were: bottom fishing (1.74), trolling (1.08) diving (0.27). The dominant species caught were: bottomfishing - red snapper; trolling - king mackerel; diving - Atlantic spadefish.

Eight species and 90 fish were caught during our troll sampling of which 55 were king mackerel. The other species and numbers caught were: bluefish (12), red snapper (6), blue runner (5), greater amberjack (5), little tunny (3), sharksucker (2), and cobia (2). Species of fish did not appear randomly distributed in the study area. The number caught (species combined) per boat in relation to zone were: large platform (2.36), small platform (1.75), Inner (0.41), Middle (0.90), and Outer (1.0). Most species caught, especially greater amberjack, cobia, and bluefish, appeared strongly attracted to the platforms.

Neither gill nets nor longlines proved successful as a sampling device for capturing pelagic fishes in the study area. Only 1.4 fish were caught per net-night of fishing with the gill nets and only 1.8 (bottom set) and 4.3 (surface set) fish were caught per line-night with longlines. Of 42 individuals caught on longlines 36 were sharks. Both gill nets and longlines were heavily damaged by sharks.

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INTRODUCTION

Certain species of pelagic and reef fishes are frequently found in association with natural and man-made objects in the sea (Shinn 1974; Moore 1975; Sonnier, Teerling and Hoese 1976; Hastings, Ogren, and Mabry 1976). This knowledge is used routinely in many areas by both commercial and recreational fishermen to improve their catches. The degree to which various species of fishes are attracted to these structures has not, however, been determined. Further, it has not been determined how important these structures are to the activities of recreational fishermen.

Methods of sampling pelagic and reef fishes in offshore areas for the purpose of estimating the standing crop of each species are not available. Several types of gear, or methods, have been used, however, to capture, or determine the relative abundance of, pelagic and reef fishes. These methods include purse seines, lampara nets, gill nets, traps, hook and line (longline, handline, and rod and reel), midwater and surface trawls, SCUBA, cameras, TV, and hydro-acoustical devices (von Brandt 1964; Slobodkin and Fishelson 1974; Alevizon and Brooks 1975; Brock 1954; Smith and Tyler 1973; Klima and Wickham 1971; Wickham, Watson and Ogren 1973). All of these techniques are limited in one way or another in respect to estimating the abundance and distribution of all components of the fish community. Each type of gear, or method of observation, is selective in that only a part of the species complex (often only 2-3 species), and only certain sizes within the species, will be sampled or observed. Each type of gear or method is usually restricted to sampling fishes from a small part of the water column.

The objectives of this study were to determine, for the Buccaneer oil field and for zones around the field (1) the amount of recreational fishing effort, the dominant species caught, and catch per unit effort, and (2) the relative abundance and size of species caught trolling. Additional objectives were to test various methods of trolling and to test the feasibility of using gill nets and longlines to sample fishes in the above-mentioned zones.

MATERIAL AND METHODS

Study Area

The Buccaneer oil field lies about 50 km (31 miles) south of Galveston's south jetty lighthouse and is isolated from other oil development platforms. The field contains two large production platforms, and 13 well platforms that are much smaller than the production platforms (Figure 1). The processing of the gas and oil pumped from the field occurs only on the larger platforms. The process for separation of oil and gas from produced water is the same for each production platform but they differ in that gas from each platform is compressed on platform B and separated oil from both platforms is stored on platform A. At present, most of the work force of the Buccaneer field lives on platform B. The small platforms, or satellite wells, connect directly by underground pipelines to the large platforms. Oil and gas are not stored at the small platforms but are transported directly to the production platforms.

Three major zones and 15 circular zones were defined for sampling purposes. The major zones (Inner, Middle, and Outer) are shown in Figure 1. The circular zones (not shown in Figure 1) are defined as the area around each platform bounded by a circle with a perimeter 65 m from the platform. The inner zone includes all areas within this zone except the circular zone areas. Depths in the study are ranged from 9 to 13.5 fm (54-81 ft).

All sampling stations except those in circular zones were positioned along compass bearings 15° apart. This created 24 stations in each major zone in addition to the circular zone stations (Figure 1).

Two types of sampling occurred: that involved in the recreational fishery survey and the biological sampling (trolling, longlining, and gillnetting).

Recreational Fishery Survey

Data for estimating the amounts of fishing effort by fishermen and divers were obtained by selecting 4 weekdays and 4 weekend-days within each of the first two 60-day sampling periods (June through September). Sampling days were similarly selected for the last three 60-day periods (November through March), but because of extremely bad weather, equipment failure and problems with boat scheduling, many of the selected days could not be utilized for sampling. Data obtained during the third period included 8 weekdays and only 1 weekend-day, while data collected during the last two 60-day periods were for only 9 days total. At least three counts (morning, mid-day, and afternoon) of boats were made on most sampling days. To make a count, our boat was run along transects through the study area. During these counts, the following types of data were obtained: number of fishermen aboard, location of boat, type of activity, and length of boat.

Data for determining species caught, catch per unit effort, and the lengths of fishing trips were obtained by personally interviewing the fishermen usually after the fishing trip but never more than 3 days following the trip. Data obtained during these interviews included: number of each species caught, hours fished, number of fishermen aboard, type of fishing, and length of boat.

Trolling

Trolling gear that has been used since late August in this study is illustrated in Figure 2. The gear was designed so that we could troll close to the platforms and sample from surface to bottom. With this gear, we simultaneously trolled two baits: at the surface; at 4, 8, 12, and 16 m below the surface; and at the bottom. The surface baits were fished from rods, the 4-m depth baits from outriggers, and the remaining baits from two snapper reel cables (downrig lines). At each depth one round scad, *Decapterus punctatus* attached to three 6/0 hooks and one strip bait attached to three 3/0 hooks were towed.

Troll samples were taken at five stations on a given sampling day. One station was randomly selected within each of the major zones (Inner, Middle, and Outer) and platform types (large and small). The order of sampling among selected stations was random. The baits were towed for 30-90 minutes at each station by running the boat in a circular pattern (radius of circle no greater than 65 m). The duration of sampling was recorded and the number of fishes caught was adjusted to a catch per boat hour (CPH) basis. Fishes caught were identified to species and lengths were determined.

Gillnetting

Gill nets were fished experimentally for 3 nights during August and September within the Inner zone. Each net used was 33 m long, 3.3 m deep, and composed of three 11-m long panels of #208 monofilament nylon webbing. Each panel in a net was of a different mesh size. Stretched mesh sizes were 5.1, 7.6, and 10.2 cm. The nets were set at the surface, at mid-water, and on the bottom except at a platform where only a single surface set was made.

Longlining

Longlines were fished experimentally for 5 nights and 1 day during August and September in the study area. The mainline of the longline was 190 m long and was made of 0.64-cm (¼ inch) diameter nylon. Gangions (54) were attached 3.6 m apart along the mainline. Each gangion was composed of a snap (for attaching to the mainline), 2 m of 0.48-cm diameter nylon, 1 m of stainless steel cable or 200 pound test monofilament nylon, and one 10/0 or 12/0 hook. Three types of hooks--snapper, treble, and straight shank--were used. When set, each mainline was attached to end buoys and the end buoys were attached to anchor lines. The lines were set in various areas of the study area and parallel with the prevailing surface current. Catch per unit effort was reported as the number of fish caught on a line during 1 night or day, i.e., catch per line-night (or line-day).

RESULTS AND INTERPRETATION

Recreational Fishing Effort

The dates that effort counts were made are shown in Table 1). The mean instantaneous number of recreational fishing boats observed in the study area ranged from 0 to 25. Mean instantaneous numbers of boats observed during the first 60-day period were similar between weekdays (6.3 boats) and weekend-days (4.7 boats). A large difference was observed during the second period (6.1 boats on weekdays vs. 16.2 boats on weekend-days). As a result of the smaller number of weekend-days sampled during the last three 60-day periods, no comparison can be made between weekday and weekend-day effort. For the weekend-days that were sampled during those periods instantaneous boat counts were high. Of all the sampling periods, the third had the lowest and the first had the highest amount of weekday fishing effort. The highest amount of fishing effort (weekdays and weekend-days combined) occurred in the late August-September period.

Three types of recreational fishing activities were identified in the study area and the boats observed were categorized into these types (Table 2). Of the total number of boats categorized, 77% were bottomfishing, 17% were trolling, and 6% were being used as a diving platform. Most of the fishing and all of the diving effort occurred in the Inner zone of the study area; only 1.7% of the bottomfishing and trolling boats were observed in the Middle and Outer zones. Within the Inner zone, the bottomfishing boats were more concentrated around the large platforms (57.5 per platform) than the small platforms (12.2 per platform); only six boats were observed fishing in the Inner zone but not within 65 m of a platform. The trolling boats often fished within 65 m of the platforms, but since they were always moving while fishing, we classified them only in regard to the major zone in which they were fishing. Most of the diving occurred around the small platforms. Divers mostly avoided the large platforms probably because of the heavy concentration of bottomfishing boats around these platforms.

A distinct pattern in the number of boats in relation to time of day was observed (Figure 3). The number of boats was low in the early morning and late afternoon and high from mid-day to mid-afternoon. This pattern is typical for recreational fisheries where small boats and distant fishing areas are involved. The lengths of boats observed in the study area were: less than 6.6 m (20 ft)--14.5%, 6.6- to 9.8-m (20-30 ft)--78.2%, and greater than 9.8 m (30 ft)--7.3%.

Initial plans were to estimate the total amount of fishing effort during each 60-day period, but this design could not be carried out for the following reasons: (1) not all randomly selected days could be sampled for reasons given previously, (2) on some sampling days all time strata (morning, mid-day, and afternoon) could not be sampled and Figure 3 illustrates the necessity for sampling at different times of the day, and (3) a good method for categorizing and sampling bad-weather days has not been established. It is known that severe weather conditions prevent all recreational fishing in the area and that these days should be excluded perior to estimating total effort. The days where intermediate weather conditions prevail are the ones that cause problems for survey people and fishermen.

In an attempt to categorize days as suitable or unsuitable for recreational fishing, wind velocity and wave height data have been used to divide the days of this project year into good, intermediate, and poor weather days (Table 3). These data were not used in this study but provide information for future planning.

Recreational Catch Per Unit Effort

Interview data were obtained from 5 July 1976 through 13 March 1977. During this period, 132 interviews were obtained and represented 453 man-days, and about 1,600 man-hours of fishing and diving. The mean numbers of fishermen or divers per boat and the mean numbers of hours fishing or diving per trip were: trolling (3.3 people and 3.6 hr); bottomfishing (3.2 people and 3.8 hr); and diving (5.3 people and 2.4 hr).

During the survey, 24 species were caught by fishermen and identified by field personnel (Table 4). In addition, at least five other species were caught, but identification to species was not obtained. It is probable that many additional species were caught, thrown back, and not reported by fishermen in the oil field.

Six species or less represented over 90% of the total number of fish caught in each type of fishing activity. These species and the mean numbers caught per fisherman hour are listed in Table 4. The most fish (species combined) were caught per fisherman hour by bottomfishing. Mean catches per hour were: bottomfishing (1.74), trolling (1.08), and diving (0.27).

Of all species reported caught in the bottomfish fishery, red snapper represents 80.3% of the total catch. The second and third most abundant fishes caught were Atlantic spadefish (6.7%) and bluefish (3.6%). The remaining species or species groups each represented less than 3% of the total catch. Of the 8 months that survey interviews were obtained, the number of red snapper caught per fisherman hour was lowest in July (0.2) and highest in December (6.8).

King mackerel, dolphin, red snapper, little tunny, sharks, and cobia were the most abundant species reported caught in the troll fishery. King mackerel dominated, representing 58% of the total number of fish caught;

number caught per fisherman hour per month ranged from 1.4 in July to 0.2 in September. Dolphin was the second most abundant species reported, but appeared in the catches only during August.

Six species (Atlantic spadefish, greater amberjack, red snapper, cobia, warsaw grouper and red drum) were reported speared by divers and the numbers of each speared per diving hour was low (Table 4).

Trolling

Troll sampling began 9 June 1976 and ended 7 March 1977. During this period, 17 days were spent trolling and a total of 90 fishes of eight species were caught (Table 5). Of the 8 species, king mackerel represented 61.1% and bluefish 13.3% of the total number of individuals caught. Red snapper, blue runner and greater amberjack represented between 5% and 7% each, and little tunny, sharksucker, and cobia each represented less than 4% of the total number caught.

Our trolling gear was modified several times during the summer. In June, we trolled 13 lures and 13 baits using 4 snapper reels and two rods and reels. We had problems with lines tangling and removed two of the snapper reels prior to our sampling in August. This reduced the numbers of lures and baits to seven each. As sample data accumulated during August, we observed that (1) the retention of fish, once hooked, on the snapper reel gangions was low, (2) few fish were being caught on the lures, and (3) fish were not being caught on the near-surface gangions towed from the snapper reels. By late August, we had modified the gangions on the snapper reel lines by adding rubber tubing, had stopped using lures and switched to baits exclusively, and had added outriggers for towing the sub-surface baits. All modifications were made between sampling days and never within a sampling day so that our comparisons between areas would be valid.

Length-frequency distributions of the species caught are given in Table 6. Of the species caught, king mackerel and cobia were the largest; greater amberjack, little tunny, and sharksucker were intermediate in size; and blue runner, red snapper, and bluefish were the smallest.

The numbers of each species caught per hour (CPH) in each zone are shown in Table 7. For king mackerel, the highest CPH occurred around the large platforms and the lowest CPH occurred in the Inner zone (among the platforms) while CPH increased from the Inner to the Outer zone. This small amount of data seems to indicate that king mackerel are strongly attracted to the platforms within a certain distance of the platforms. This platform attraction hypothesis possibly explains the high CPH adjacent to the platforms, and the increase in CPH as the distance from the Inner zone increases. Two of the eight species (amberjack and cobia) were caught only in the circular zones around the platforms. One species (sharksucker) was caught only in the Middle zone.

Gillnetting

Gill nets were not effective in capturing pelagic fishes in the study area. Three net-nights of fishing in the upper 3.3 m of the water column produced one sharksucker and one Atlantic sharpnose shark (*Rhizoprionodon terraenovae*). Two net-nights of fishing in the bottom 3.3 m of the water column produced one Atlantic sharpnose shark, one sharksucker, one Atlantic bumper (*Chloroscombrus chrysurus*), 1 sand seatrout (*Cynoscion arenarius*), and 1 threadfin shad (*Dorosoma petenense*). Both nets set at the bottom were each more than 40% destroyed by sharks and could not be used for fishing a second night. Based on the experience obtained during this study and previous studies gill nets are not considered as an effective sampling method for obtaining baseline data in offshore waters of the Gulf of Mexico.

Longlining

Longlines caught sharks, but few other fishes, in the study area (Table 8). Four species and 36 individual sharks, three sharksuckers, two king mackerel, and one little tunny were caught in 13 line-nights (one longline fishes for 1 night) and 1 line-day. Total numbers of each shark species caught were: Atlantic sharpnose (15), tiger (9), blacknose (*Carcharhinus acronotus*) (8), and bull (4).

Longline efficiency, as measured by catch per unit effort, was low even for capturing sharks. The number of sharks caught per line-night (54 hooks) was 1.8 at the bottom and 4.3 at the surface. The following factors probably contributed to this low catch rate: (1) mainlines were broken and sections of the line were lost, and an average of about eight hooks (often the entire gangion) were lost per line night (these losses were apparently caused by sharks); (2) the inability to remove fish and rebait the lines at 4-hr intervals during the night as originally planned because of high seas, improper equipment for handling the gear, or both.

LITERATURE CITED

Alevizon, W. S. and M. G. Brooks.
1975. The comparative structure of two western Atlantic reef-fish assemblages. Bull. Mar. Sci., 25 (4): 482-490.

Brock, V. E.
1954. A preliminary report on a method of estimating reef fish populations. J. Wildl. Mgmt., 18: 297-308.

Hastings, R. W., L. H. Ogren, and M. T. Mabry.
1976. Observations on the fish fauna associated with offshore platforms in the northeastern Gulf of Mexico. Fish. Bull., 74 (2): 387-402.

Klima, E. F. and D. A. Wickham.
1971. Attraction of coastal pelagic fishes with artificial structures. Trans. Amer. Fish. Soc., 100: 86-96.

Shinn, E. A.
1974. Oil structures as artificial reefs. Pages 91-96. In: L. Colunga and R. Stone (ed.), Proceedings of an International Conference on Artificial Reefs. Center for Marine Resources, Texas A&M Univ., National Marine Fisheries Serv., and Texas Coastal and Marine Council.

Slobodkin, L. B. and L. Fishelson.
1974. The effect of the cleaner-fish Labroides dimidiatus on the point diversity of fishes on the reef front at Eilat, Amer. Nat., 108 (961): 369-376.

Smith, C. L. and J. C. Tyler.
1973. Direct observations of resource sharing in coral reef fish. Helgolander wiss. Meeresunters., 24: 264-275.

Sonnier, F, J. Teerling, and H. D. Hoese.
1976. Observations on the offshore reef and platform fish fauna of Louisiana. Copeia, 1976: 105-111.

von Brandt, A.
1964. Fish catching methods of the world. Fishing News (Books) Ltd., 110 Fleet Street, London EC4. 191 pp.

Wickham, D. A., J. W. Watson, Jr., and L. H. Ogren.
1973. The efficacy of midwater artificial structures for attracting pelagic sport fish. Trans. Amer. Fish. Soc., 102 (3): 563-572.

APPENDIX

Table 1. Mean numbers of boats counted in the study area by 60-day period.

60-day Period	Date	Average instantaneous number of boats	
		Weekday	Weekend-day
1	Jun 12	----	1.0
	14	12.3	----
	22	1.7	----
	Jul 3	----	1.0
	6	----	2.0
	18	----	15.0
	27	8.3	----
	Aug 2	3.0	----
	Mean	6.3	4.7
2	Aug 21	----	20.3
	28	----	25.0
	Sep 6	13.3	----
	12	----	12.3
	23	0.0	----
	24	5.0	----
	25	----	22.3
	26	----	1.0
	Mean	6.1	16.2
3	Oct 21	0.0	----
	22	0.0	----
	26	0.0	----
	Nov 1	0.0	----
	2	0.0	----
	6	----	14.7
	18	0.0	----
	23	0.7	----
	Dec 3	1.3	----
	Mean	0.3	14.7
4	Dec 9	0.5	----
	16	1.0	----
	17	4.0	----
	Jan 21	2.0	----
	22	----	8.0
	Mean	1.9	8.0
5 1/	Feb 13	----	7.0
	Mar 2	0.0	----
	7	3.0	----
	8	6.5	----
	Mean	3.2	7.0

1/ Less than 60 days; study terminated.

Table 2. Number of boats counted in relation to types of fishing activity and spatial distribution.

Type of Activity	Zone and Platform Type				
	Inner			Middle	Outer
	Large	Small	Among[1]		
Bottomfishing	115	159	6	1	0
Trolling	---	---	56	4	1
Diving	2	18	2	0	0

[1] Location within Inner zone not identified.

Table 3. Daily Weather Categorizations for the Days of This Project Year

	S	M	T	W	T	F	S
JUN 1976			1 Ⓟ	2 Ⓟ	3 I	4 G	5 I
	6 I	7 P	8 I	9 G	10 G	11 I	12 P
	13 I	14 I	15 P	16 I	17 I	18 P	19 I
	20 I	21 I	22 Ⓟ	23 Ⓟ	24 Ⓟ	25 I	26 I
JUL	27 I	28 I	29 I	30 I	1 I	2 P	3 P
	4 I	5 I	6 G	7 I	8 P	9 I	10 I
	11 I	12 I	13 I	14 I	15 I	16 I	17 I
	18 P	19 I	20 G	21 P	22 G	23 G	24 I
	25 G	26 I	27 I	28 I	29 I	30 I	31 I
AUG	1 I	2 P	3 I	4 G	5 I	6 I	7 I
	8 G	9 I	10 I	11 I	12 I	13 I	14 I
	15 I	16 I	17 G	18 I	19 I	20 I	21 I
	22 G	23 I	24 I	25 I	26 G	27 I	28 Ⓟ
SEP	29 Ⓟ	30 I	31 I	1 I	2 I	3 I	4 P
	5 G	6 G	7 G	8 G	9 G	10 I	11 I
	12 I	13 I	14 I	15 G	16 I	17 I	18 I
	19 I	20 I	21 I	22 I	23 I	24 I	25 G
OCT	26 I	27 I	28 Ⓟ	29 I	30 I	1 G	2 G
	3 I	4 P	5 P	6 I	7 Ⓟ	8 Ⓟ	9 I
	10 G	11 G	12 I	13 I	14 G	15 Ⓟ	16 Ⓟ
	17 Ⓟ	18 I	19 Ⓟ	20 Ⓟ	21 G	22 P	23 Ⓟ
	24 Ⓟ	25 I	26 I	27 Ⓟ	28 Ⓟ	29 Ⓟ	30 Ⓟ
	31 I						

	S	M	T	W	T	F	S
NOV		1 I	2 G	3 G	4 I	5 I	6 G
	7 G	8 Ⓟ	9 I	10 I	11 Ⓟ	12 Ⓟ	13 Ⓟ
	14 Ⓟ	15 I	16 I	17 Ⓟ	18 Ⓟ	19 Ⓟ	20 G
	21 Ⓟ	22 I	23 I	24 I	25 I	26 Ⓟ	27 Ⓟ
DEC	28 Ⓟ	29 Ⓟ	30 G	1 I	2 I	3 G	4 I
	5 P	6 Ⓟ	7 Ⓟ	8 G	9 I	10 Ⓟ	11 Ⓟ
	12 I	13 P	14 Ⓟ	15 I	16 I	17 G	18 I
	19 Ⓟ	20 Ⓟ	21 Ⓟ	22 I	23 Ⓟ	24 Ⓟ	25 Ⓟ
JAN 1977	26 Ⓟ	27 Ⓟ	28 Ⓟ	29 Ⓟ	30 Ⓟ	31 Ⓟ	1 Ⓟ
	2 Ⓟ	3 Ⓟ	4 I	5 I	6 P	7 I	8 Ⓟ
	9 Ⓟ	10 Ⓟ	11 Ⓟ	12 Ⓟ	13 Ⓟ	14 Ⓟ	15 G
	16 Ⓟ	17 Ⓟ	18 Ⓟ	19 Ⓟ	20 G	21 G	22 I
	23 I	24 I	25 G	26 G	27 I	28 P	29 P
FEB	30 Ⓟ	31 Ⓟ	1 I	2 P	3 Ⓟ	4 I	5 I
	6 I	7 P	8 I	9 I	10 Ⓟ	11 Ⓟ	12 Ⓟ
	13 I	14 Ⓟ	15 Ⓟ	16 I	17 P	18 Ⓟ	19 I
	20 I	21 I	22 Ⓟ	23 Ⓟ	24 Ⓟ	25 Ⓟ	26 Ⓟ
MAR	27 Ⓟ	28 I	1 Ⓟ	2 Ⓟ	3 Ⓟ	4 Ⓟ	5 Ⓟ
	6 Ⓟ	7 G	8 G	9 P	10 Ⓟ	11 Ⓟ	12 I
	13 G	14 I	15 G	16 I	17 Ⓟ	18 Ⓟ	19 Ⓟ
	20 P	21 Ⓟ	22 Ⓟ	23 I	24 Ⓟ	25 Ⓟ	26 Ⓟ
	27 Ⓟ	28 Ⓟ	29 G	30 G	31 Ⓟ		

Wind Speed	Sea Condition	Symbol
Up to 12 mph	Good - Seas 3 ft. and less	G
12 to 18 mph	Intermediate - 3 to 6 ft. seas	I
Over 18 mph	Poor - Seas 6 ft. and over	P
Over 20 mph	Small Craft Advisories Posted	Ⓟ

Table 4. Common and scientific names of species reported caught, and numbers caught by type of activity, in the study area.

Species	Number caught by type of fishing		
	Bottom fishing	Trolling	Diving
Red Snapper (*Lutjanus campechanus*	828	66	8
King mackerel (*Scomberomorus cavalla*)	12	523	0
Dolphin (*Corphaena hippurus*)	0	161	0
Atlantic spadefish (*Chaetodipterus faber*)	69	5	12
Bluefish (*Pomatomus saltatrix*)	37	1	0
Little tunny (*Euthynnus alletteratus*)	3	34	0
Cobia (*Rachycentron canadum*)	2	26	4
Pigfish (*Orthopristis chrysoptera*)	24	0	0
Greater amberjack (*Seriola dumerili*)	1	15	8
Spanish mackerel (*Scomberomorus maculatus*)	0	20	0
Sheepshead (*Archosargus probatocephalus*)	16	0	0
Bull shark (*Carcharhinus leucas*)	5	7	0
Blue runner (*Caranx crysos*)	5	3	0
Warsaw grouper (*Epinephelus nigritus*)	4	0	3
Crevalle jack *Caranx hippos*)	0	5	0
Red drum (*Sciaenops ocellata*)	3	0	1
Florida pompano (*Trachinotus carolinus*)	0	2	0
Sailfish (*Istiophorus platypterus*)	0	2	0
Sharksucker (*Echeneis naucrates*)	0	2	0
Gray triggerfish (*Balistes capriscus*)	2	0	0
Sandbar shark (*Carcharhinus milberti*)	0	1	0
Gray snapper (*Lutjanus griseus*)	1	0	0
Tiger shark (*Galeocerdo cuvieri*)	1	0	0
Jewfish (*Epinephalus itajara*)	1	0	0
Black drum (*Pogonias cromis*)	1	0	0
Hammerhead shark (*Sphyrna* sp.)	2	0	0
Shark[1]	2	22	0
Triggerfish[1]	10	7	0
Drum[1]	1	0	0
Seatrout[1]	1	0	0
Total	1,031	902	36

---

[1] Not identified to genus.

Table 5. Species composition of catch and numbers of fish caught per fisherman hour in relation to type of fishing.

Species and type of activity	Percent of total number caught	Number caught per fisherman hour
Bottomfishing		
Red snapper	80.3	1.41
Atlantic spadefish	6.7	0.12
Bluefish	3.6	0.07
Pigfish	2.3	0.04
Sheepshead	1.5	0.02
King mackerel	1.2	0.02
Other	4.4	0.06
		1.74
Trolling		
King mackerel	58.0	0.63
Dolphin	17.8	0.19
Red snapper	7.3	0.08
Little tunny	3.8	0.04
Sharks	2.9	0.03
Cobia	3.2	0.03
Other	7.0	0.08
		1.08
Diving		
Atlantic spadefish	33.3	0.09
Greater amberjack	22.2	0.06
Red snapper	22.2	0.06
Cobia	11.1	0.03
Warsaw grouper	8.3	0.02
Red drum	2.8	0.01
		0.27

Table 6. Species and number of individuals caught during total sampling and percent composition of the catch.

Species	Number caught	Percent composition
King mackerel	55	61.1
Bluefish	12	13.3
Red Snapper	6	6.7
Blue runner	5	5.5
Greater amberjack	5	5.5
Little tunny	3	3.3
Sharksucker	2	2.2
Cobia	2	2.2
	90	99.8

Table 7. Length-frequency distribution of each species caught.

	Fork length interval in centimeters (1 cm = .3937 inch)															
	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0	110.0
Species	34.9	39.9	44.9	49.9	54.9	59.9	64.9	69.9	74.9	79.9	84.9	89.9	94.9	99.9	104.9	114.9
King mackerel								4	10	11	11	6	3	5	6	1
Amberjack						1	1		1							
Bluerunner	1	2	2													
Little tunny				2					1							
Red snapper		1	2	2		1										
Cobia													1			
Sharksucker[1]							2									
Bluefish		3	3	6												

---

[1] Total length.

Table 8. Troll catch per unit effort by species and zone in the study area.

	ZONE				
Species	Large Platform	Small Platform	Inner	Middle	Outer
King mackerel	1.14	1.04	0.25	0.66	0.86
Bluefish	0.36	0.39	0.08	0.00	0.00
Red snapper	0.36	0.00	0.00	0.08	0.00
Greater amberjack	0.29	0.06	0.00	0.00	0.00
Blue runner	0.14	0.13	0.00	0.00	0.07
Little tunny	0.07	0.00	0.08	0.00	0.07
Sharksucker	0.00	0.00	0.00	0.16	0.00
Cobia	0.00	0.13	0.00	0.00	0.00
	2.36	1.75	0.41	0.90	1.00

Table 9. Species and numbers of fishes caught with longlines at surface and bottom depths in the study area.

Date	Species	Surface		Bottom	
		Number Longlines	Number Caught	Number Longlines	Number Caught
Aug. 4-5	Bull shark	1	2	1	0
	Tiger shark		1		0
	Little tunny		1		0
	Sharksucker		1		0
Aug. 5[1/]	Tiger shark	1	1		
Aug. 5-6	Sharksucker	1	1	1	0
Aug. 31- Sept. 1	Blacknose shark	1	3	1	3
	Atlantic sharpnose shark		1		
	Tiger shark		1		
	Bull shark		1		
Sept. 23-24	Tiger shark	3	3	3	3
	Blacknose shark		1		1
	Atlantic sharpnose shark		12		2
	Bull shark				1
	Sharksucker				1
	King mackerel				2
Totals		7	29	6	13

[1/] Daytime set.

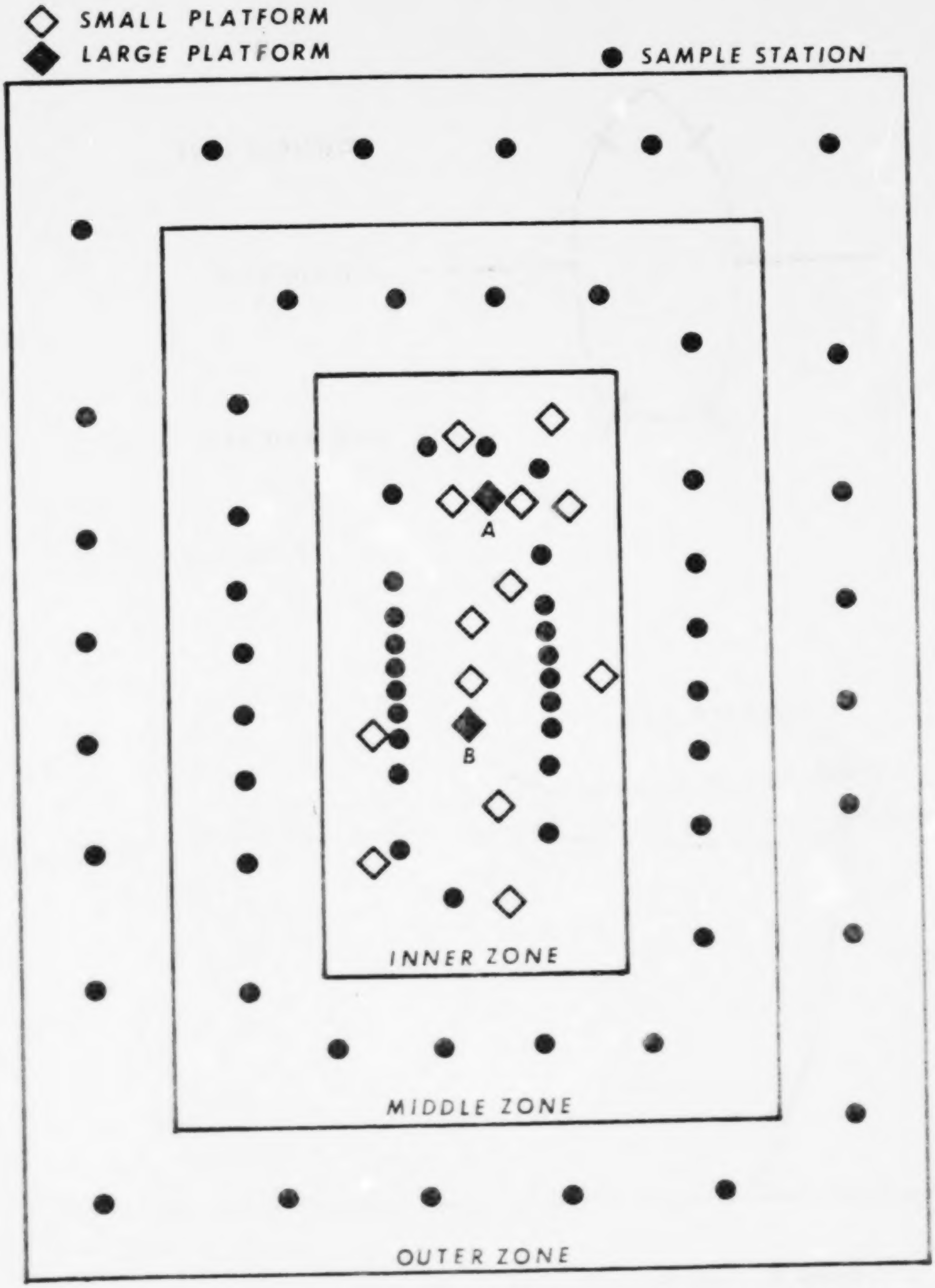
SMALL PLATFORM
LARGE PLATFORM
SAMPLE STATION
A
B
INNER ZONE
MIDDLE ZONE
OUTER ZONE

Figure 1. Zones, platform locations, and sampling stations in the Buccaneer oil field study area.

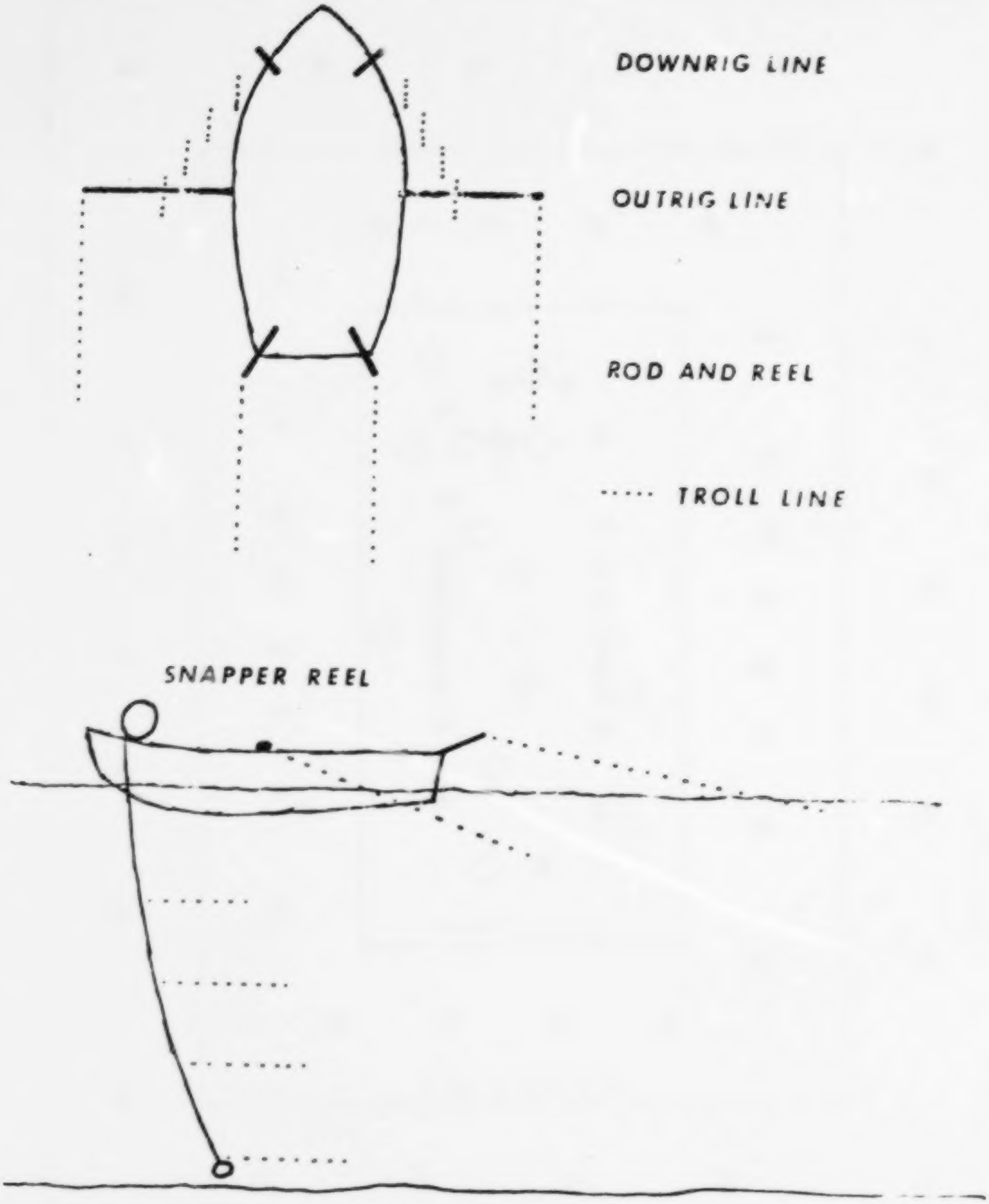
DOWNRIG LINE
OUTRIG LINE
ROD AND REEL
TROLL LINE
SNAPPER REEL

Figure 2. Schematic diagram of the trolling gear used for sampling.

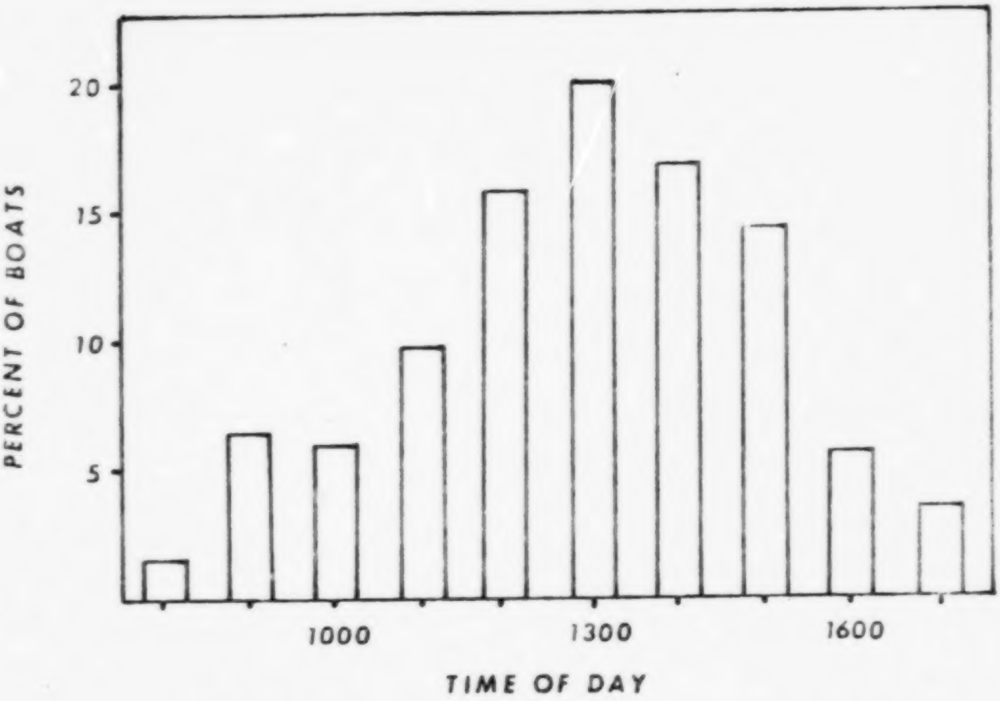

Figure 3. Amount of fishing effort in relation to time of day.

ICHTHYOPLANKTON

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John H. Finucane

Associate Investigator

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EXECUTIVE SUMMARY

Our ichthyoplankton data indicate that the oil field and adjacent coastal waters are highly productive. During this study, 36 families, 43 genera and 26 species of fish larvae were identified. The anchovies comprised 38% of all larvae collected and together with the gobies, bothids, carangids and sciaenids accounted for 73% of the total larval catch. Seasonal sampling showed that the highest larval abundance (55.5%) occurred during August and the highest egg abundance (45.3%) occurred during May. The lowest larval numbers (6.5%) and the lowest egg numbers (2.5%) were present during February.

Species diversity was greater in the field area as compared to the control area during the entire study. Larval numbers per 1,000 m^3 based on the total amount of water filtered and all larvae collected were higher during May and December in the oil field when compared to the control area. Egg numbers per 1,000 m^3 were only higher during May in the oil field as compared to the control area. When selected MARMAP stations of similar depths were used as control stations and compared with the EPA oil field stations, egg numbers were highly significant in the field area at the 95% confidence level.

Based on larval sizes and egg abundance, the study area is a major spawning ground for callionymids, clupeids, engraulids, scombrids, sciaenids and soleids. Larvae of the little tuna, *Euthynnus alletteratus*; the scaled sardine, *Harengula jaguana*; the thread herring, *Opisthonema oglinum*; the sardine, *Sardinella* sp., and the silver perch, *Bairdiella chrysura*, were only caught in the oil field. These data suggest that the oil platforms and other structures serve as artificial reefs and are attracting fish that utilize this area for spawning, feeding and shelter.

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INTRODUCTION

This report covers only the ichthyoplankton portion of a multidiscipline environmental assessment of the Buccaneer Oil Field in the northwestern Gulf of Mexico. The study area for this baseline survey is about 51.5 kilometers (km) or 32 miles southeast from Galveston, Texas, in water depths averaging 17 meters. The Buccaneer field was selected because it has been producing oil and gas for about 15 years and is isolated from other oil fields.

The primary objectives of this study were to determine the seasonal abundance, occurrence, distribution and species composition of ichthyoplankton in an active oil field and adjacent control area. Spawning times and locations were also documented. The long-term effects of offshore drilling and oil production on fisheries in the Gulf of Mexico are still largely unknown. Documented studies of oil pollution effects on planktonic organisms are further limited (U.S. Environmental Protection Agency, 1975). Ecological data from the Buccaneer field and other study areas off Texas should also be useful in supporting fishery productivity estimates.

A series of 8 stations (4 field and 4 control) were occupied on a seasonal basis during May, August, November/December 1976, and February 1977 (Figure 1). The field stations (B, C, F, G) were located at the approximate midpoint of the oil field near one of the two major permanent type platforms from which drilling and production activities are conducted. The control stations (A, D, E, H) were situated along two tracks bisecting the field area. Each of these control stations was 9.3 kilometers (km) or 5 nautical miles from the oil field area. To provide additional coverage of the area, 15 MARMAP stations were sampled along three transects in conjunction with the EPA stations (Figure 2). These stations also can be considered as control stations. The exact station locations and depths in these two study areas are given in Tables 1 and 2. Additional ichthyoplankton data for these areas such as net mesh size, collection time, water filtered and numbers of eggs and larvae are shown for each cruise in Tables 3-10.

Little published information is available on the fish eggs and larvae of the northwest Gulf of Mexico. A survey that we completed in 1975 for the Bureau of Land Management provides the only comprehensive coverage of ichthyoplankton in the neritic and oceanic waters off Texas (U.S. Department of Commerce, 1976). The literature on juvenile and adult marine fishes of Texas is extensive and helped us to determine the known fishes in the study areas. Early studies by Gunter (1945, 1950 and 1959) established the species diversity and richness of the fish fauna off the South Texas coast. Hoese (1958) compiled a checklist of 424 species of marine fishes caught in Texas waters and

Parker (1965) compiled a checklist of the fishes of Galveston Bay, Texas. More recently, Galloway et al. (1972) and Walls (1975) added additional reference material on the fishes of Texas and the northern gulf. The papers by Briggs (1958) and Powell et al. (1972) were useful in determining the known ranges of various species in the gulf. Hoese (1965) gives some spawning times of marine fishes in the Port Aransas, Texas, area and Arnold et al. (1960) listed larval and juvenile fishes caught in Galveston Lagoon.

Identification of fish larvae from the study area was made whenever possible from our own reference collection compiled from other plankton studies in the Gulf of Mexico. Because knowledge of the early life history of many marine fishes is still unknown, some identification was based on available references of similar species from other areas. Particularly useful was the paper on the meristic characters of some marine fishes of the western North Atlantic by Miller and Jorgenson, 1973. Other papers covering the early life histories of certain species were helpful. They included: Aprieto (1973) who described the early development of some carangid fishes, Jannke (1971) on sciaenid fishes of the Everglades and Houde and Fore (1973) on the eggs and larvae of clupeid fishes in the Gulf of Mexico. Additional references used to identify larvae were Wollam (1970) for Spanish and king mackerels; Mansueti and Hardy (1967) on the development of fishes of the Chesapeake Bay region and Scotton et al. (1973) on the guide to fish larvae of Delaware Bay. Various groups such as the bothids, bregmacerotids, myctophids, serranids, scombrids and eel leptocephali were sent to specialists to verify our identification. Some larvae and most eggs were not classified to family level due to the lack of reference material of known identity. Many of the larvae were too small or mutilated to identify.

The classification of most larval fishes followed that given by Bailey et al. (1970). For archival of larval data the bionumeric code developed by Bullis et al. (1972) was used. A complete tabulation of all the eggs and larval taxon collected from bongo tows during this study is shown by date, station, mesh size and numbers per 1,000 m^3 in Appendix table 34.

MATERIALS AND METHODS

Ichthyoplankton collections were made with bongo and neuston net samplers at each station using standard MARMAP sampling gear and techniques (Jossi et al. 1975). The paired bongo samplers have a mouth opening of 61 cm and mesh sizes of 0.333 mm and 0.505 mm (Posgay et al. 1968). A General Oceanics digital flowmeter was placed in the mouth of each bongo net to determine the volume of water filtered during each tow. All flowmeters were calibrated prior to each cruise. A Bendix time-depth recorder was used during Cruise 4 to record the characteristics of the bongo tows. Neuston tows were made on the surface with the net partially submerged for a duration of 10 minutes at each station. The frame of the neuston net had a mouth opening of 0.5 x 1.0 m and mesh size was 0.505 mm. No flowmeter was attached to this net and the neuston plankton samples were only used on a qualitative basis. Neuston tows are an important supplement to the bongo tows since they often collect late stage larvae and juveniles that are useful in larval identification. Net tows were made during both day and night. For the first three cruises, about equal day and night samples were collected. A station was sampled at the time the ship occupied it. Station sampling sequence varied between cruises.

Double oblique net tows were made on all cruises with the bongo gear. Each tow was designed to sample the depth strata equally from the surface to near the bottom. A tow consisted of wire release at 50 m per min. until the desired depth was reached, followed by wire retrieval at 20 m per min. A constant monitoring of the wire angle during each bongo tow was done with a hand held inclinometer or a ball and tube pendulum type indicator. In this way ship speed and direction could be changed when necessary to maintain as close to a 45° wire angle as possible. A stopwatch was also used to precisely time each tow. Nets were towed from the stern of each vessel except during Cruise 4 when they were towed from the side of the OREGON II.

Plankton nets were washed down with seawater before the cod-ends were removed at the end of a tow. The plankton was transferred immediately to jars containing 7% buffered formalin in seawater. In the laboratory, displacement volumes (Table 11) were determined by means of a Yentsch plankton volume gauge after first removing large ctenophores, sargassum, and detrital material (Yentsch and Hebard, 1957). Ichthyoplankton was sorted to the lowest possible taxon from the entire sample; no aliquots or splits were taken. Fish larvae were measured to the nearest 0.1 mm (standard length) or the nearest 1 mm when over 10 mm in size.

Water temperature and salinities were taken during each cruise. Temperatures were measured with expendable, temperature-sensing bathythermographs (XBT's). Surface bucket temperatures were also taken by hand thermometers graduated to 0.1°C. Salinities of surface and bottom waters were taken by Nansen bottle casts and were determined by the Goldberg Refractometer method. A conductivity-temperature meter was also used to record salinity at 3 m intervals through the water column.

RESULTS AND INTERPRETATION

Abundance and species composition

During this survey, a total of 3,045 fish larvae and 24,316 eggs were collected from the quarterly sampling cruises in the Buccaneer oil field area. All larval taxa are given for each cruise in Tables 12 to 15 by their descending order of abundance. Taxa representing 36 families, 43 genera and 26 species of larval fishes were identified (Table 16). These data show that the engraulids represented 38% of the total catch for all gear types and together with the gobies, clupeids, bothids, carangids and sciaenids accounted for 73% of all larvae collected. Species diversity from the bongo net catch was greater in the oil field area as compared to the control area (Table 17). For example, 33 genera and 20 species were caught in the field area as compared to 24 genera and 13 species in the control area during the entire sampling period.

Larval composition and abundance varied by season and gear type (Tables 18 to 22). For example, during May the tetraodontids comprised 7.5% of the 0.505 mm bongo catch; 3.7% of the 0.333 mm catch and 11.9% of the neuston catch. The engraulids were the dominant family during August for all gear types but they were completely absent during February. Larval abundance and composition also varied between the oil field and control area (Tables 23 and 24). For example, the little tuna, *Euthynnus alletteratus*, was the most abundant scombrid in the oil field but was completely absent in the control area. In contrast, the rough scad, *Trachurus lathami*, was caught only in the control area. Most of the other genera and species were the same between the two sampling areas.

The species composition of the neuston samples was similar to the bongo samples but their relative abundance for the top ten families indicates that the neuston tows collected fewer engraulids and no scombrids. In contrast, no cynoglossids were caught in the neuston tows and no exocoetids or gadids were caught in the bongo tows (Tables 25 and 26).

When comparing the 0.505 mm bongo catches from the Transect VII MARMAP samples with the bongo catches from the EPA control area, other differences in species composition and relative abundance were noted (Tables 26 and 27). For example, Clupeidae was the dominant family in the MARMAP samples while Engraulidae was the dominant family in the EPA samples. Greater bothid species diversity was present in the MARMAP samples; also synodontids, stromateids and bregmacerotids occurred only in the MARMAP sampling area. This higher species diversity was due mainly to the greater depths sampled and further offshore spawning of some fish species.

To show the larval abundance for each cruise, six dominant families: Bothidae, Clupeidae, Engraulidae, Sciaenidae, Scombridae and Serranidae and associated genera and species were plotted by station in the control and field areas by their numbers per 1,000 m^3 (Figs. 3 to 54). These larvae were chosen because of their importance as commercial, sport or forage fish. Bothids and sciaenids were more abundant during December and engraulid larvae in August in the field area as compared to the control area (Figs. 5, 24 and 29). The reverse pattern was noted for the serranids which were more abundant during May in the control area as compared to the oil field (Fig. 51).

When the abundance of representative genera and species of the same families was compared between field and control stations, little difference was noted as compared to the family abundance patterns. For example, larvae of the genera Paralichthys and Syacium were similar in relative abundance between field and control areas to all the bothids (Figs. 3-14). These data also indicate that little species preference exists for either the field or control areas within the same family.

Larval and egg abundance was also recorded on a quarterly basis and for all quarters between the control and oil field stations in numbers per 1,000 m^3 of water filtered (Tables 28, 29 and Figs. 55 to 64). These data show that only during May were fish eggs higher in the field as compared to the control area. Larval abundance followed a different pattern and was higher in the field area only during May and December. During the entire sampling period, 972 larvae per 1,000 m^3 were caught in the control area as compared to 1,032 larvae per 1,000 m^3 for the field area.

Comparing egg abundance between representative MARMAP stations and EPA field stations of similar sampling depths, a statistical significant difference was noted only during May. During this period, 16,013 eggs per 1,000 m^3 were recorded in the EPA stations as compared to 3,855 eggs per 1,000 m^3 in the MARMAP station area (Table 30).

Seasonal occurrence and distribution

The four sampling cruises gave some seasonal coverage during the spring, summer, fall and winter (Tables 3 to 6). The highest larval abundance was noted during August and the highest egg abundance during May when 55.5% of the larvae and 45.3% of the eggs were collected. The lowest larval numbers (6.5%) and the lowest egg numbers (2.5%) were noted during February. Species diversity was highest during May and lowest during December (Table 17).

Salinity and temperature influence the seasonal occurrence of fish.

During this study when salinity and temperature ranges were compared by taxon, some species preference patterns were noted (Table 31). Larvae of the croaker, Micropogon undulatus, occurred only at temperatures ranging from 13.7-17.5°C and at salinities from 31.9-36.7°/oo. In contrast, thread herring, Opisthonema oglinum, were collected only at temperatures from 28.5-30.5°C and at salinities from 29.0-32.8°/oo. These salinity and temperature preferences are probably more related to spawning cycles than they are to seasonal occurrence.

Larval dominance varied by season (Tables 12 to 15). For example, the gobies were the dominant family during the spring and fall, the fifth highest in the summer and only the tenth highest in the winter. The anchovies were the most abundant family in the summer and were completely absent from the study area in the winter. The reverse pattern was noted for the menhaden, Brevoortia sp., which were dominant during the winter but completely absent during the spring and summer.

Distribution of all larval taxa by station in the field and control areas is given in Table 32. These data show some preference by station and sampling areas. All the lanternfishes (Myctophidae) and barracudas (Sphyraenidae) occurred only in the field areas while other fishes such as the snappers (Lutjanidae) and triggerfishes (Balistidae) were only found in the control area.

When comparing egg distribution by selected families, some differences were noted (Table 33). The dragonets (Callionymidae) were present at only two stations in the entire sampling area in May while the anchovies (Engraulidae) were found in the samples from 2 control and 3 field stations. During December and February, the herrings (Clupeidae) were present at all stations but one in the control area. Eggs of the sole (Soleidae) showed a different pattern. They were completely absent from the field area in May and February.

Spawning

Based on egg abundance, the study area is a major spawning ground for many fishes (Table 33). Spawning times and intensities varied between fish species. For example, the eggs of clupeids were collected during all cruises which indicates that spawning occurred throughout most of the year. Spawning for these herring appeared to peak in December. In contrast, scombrid eggs were collected only during May and August and reached their peak abundance in August. The engraulids are similar to clupeids in that they have a long spawning pattern but anchovies did not spawn in December. When total egg abundance is compared, spawning in the entire sampling area reached a peak in the spring (Fig. 55).

The size range of larvae and their relative abundance can give another indication of spawning time, place and intensity. Bothid larvae were present during all sampling cruises which indicates spawning throughout the year (Figs. 3 to 6). When the genera *Paralichthys* and *Syacium* of the bothid family are compared, *Paralichthys* spawned mainly during the fall and winter while *Syacium* appeared to spawn only in the spring and summer (Figs. 7 to 14). A fall and winter spawning pattern was also noted for the menhaden, *Brevoortia*, and the croaker, *M. undulatus* (Figs. 19 to 22 and 31 to 34). The size range and abundance of tuna and mackerel larvae indicate that spawning occurred only in the summer. For example, the Spanish and king mackerels, *Scomberomorus maculatus* and *S. cavalla*, and the little tuna, *Euthynnus alletteratus*, appeared to spawn only in August (Figs. 39 to 50).

If the fish eggs and larvae are compared between the field and control stations, some spawning preferences for the field areas are noted. For example, clupeid eggs were only collected in the field samples during May. Larvae of the scaled sardine, *Harengula jaguana*; the thread herring, *Opisthonema oglinum*; the sardine, *Sardinella* sp., and the little tuna, *E. alletteratus*, occurred only in the field area. These data suggest that the oil platforms and other structures serve as artificial reefs and are attracting fish that utilize this area for spawning, feeding and shelter.

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LITERATURE CITED

APRIETO, V. L.
1973. Early development of carangid fishes of the Gulf of Mexico and the South Atlantic coast of the United States. Ph.D. Thesis, Univ. Miami, Coral Gables, 179 p.

ARNOLD, E. L., Jr., R. S. WHEELER, and K. N. BAXTER.
1960. Observations on fishes and other biota of East Lagoon, Galveston Island. U.S. Fish and Wildl. Ser. SSR-Fish No. 344, 30 p.

BAILEY, R. M., J. E. FITCH, E. S. HERALD, E. A. LACHNER, C. C. LINDSEY, and W. B. SCOTT.
1970. A list of common and scientific names of fishes from the U.S. and Canada. Amer. Fish. Soc., Spec. Publ. No. 6. 150 p.

BRIGGS, J. C.
1958. A list of Florida fishes and their distribution. Bull. Fla. St. Mus., Biol. Sci. 2(8):223-318.

BULLIS, H. R., Jr., R. B. ROE, and J. C. GATLIN.
1972. The Southeast Fisheries Center Bionumeric Code. Part I: Fishes. NOAA Tech. Rep. NMFS SSR-Fish No. 659, 95 p.

GALLOWAY, B. J., J. C. PARKER, and D. MOORE.
1972. Key to the estuarine and marine fishes of Texas. Texas A & M Univ., 177 p.

GUNTER, G.
1945. Studies on marine fishes of Texas. Publ. Inst. Mar. Sci., Univ. Texas. 1(1):1-190.

____
1950. Distributions and abundance of fishes on the Aransas National Wildlife Refuge, with life history notes. Publ. Inst. Mar. Sci., Univ. Texas. 1(2):89-101.

____
1959. Population studies of the shallow water fishes of an outer beach in south Texas. Publ. Inst. Mar. Sci., Univ. Texas. 5:186-193.

HOESE, H. D.
1958. A partially annotated checklist of the marine fishes of Texas. Publ. Inst. Mar. Sci., Univ. Texas. 5:312-352.

―――――
1965. Spawning of marine fishes in the Port Aransas, Texas, area as determined by the distribution of young and larvae. Ph.D. Thesis, Univ. Texas. 144 p.

HOUDE, E. D., and P. L. FORE.
1973. Guide to identity of eggs and larvae of some Gulf of Mexico clupeid fishes. Fla. Dep. Nat. Resour., Mar. Res. Lab., Leafl. Ser. 4, Part 1, No. 23, 14 p.

JANNKE, T. E.
1971. Abundance of young sciaenid fishes of Everglades National Park, Florida, in relation to season and other variables. Sea Grant Tech. Bull. 11, Univ. Miami. 128 p.

JOSSI, J. W., R. R. MARAK, and H. PETERSEN, Jr.
1975. At-sea data collection and laboratory procedures. In: MARMAP Survey I Manual, NMFS, Washington, D.C. 115 p.

MANSUETI, A. J., and J. D. HARDY, Jr.
1967. Development of fishes of the Chesapeake Bay region. An atlas of egg, larval and juvenile stages. Part I. Nat. Resour. Inst., Univ. Md. 202 p.

MILLER, G. L., and S. C. JORGENSON.
1973. Meristic characters of some marine fishes of the western Atlantic Ocean. Fish. Bull. U.S. 71:301-312.

PARKER, J. C.
1965. An annotated checklist of the fishes of Galveston Bay, Texas. Publ. Inst. Mar. Sci. 10:201-220.

POSGAY, J. A., R. R. MARAK, and R. C. HENNEMUTH.
1968. Development and tests of new zooplankton samplers. Int. Comm. NW. Atlas. Fish. Res. Doc. 68/85. 7 p.

POWELL, D., L. M. DWINELL, and S. E. DWINELL.
1972. An annotated listing of the fish reference collection at the Fla. Dep. Nat. Resour., Mar. Res. Lab. State of Fla., Dep. Nat. Resour., Spec. Sci. Rep. No. 36. 179 p.

SCOTTON, L. N., R. E. SMITH, N. S. SMITH, K. S. PRICE, and D. P. de SYLVA.
1973. Pictorial guide to fish larvae of Delaware Bay, with information and bibliographies useful for the study of fish larvae. Delaware Bay Rep. Series, vol. 7, College Marine Studies, Univ. of Delaware. 206 p.

U.S. DEPARTMENT of COMMERCE.
1976. Environmental studies of the South Texas outer continental shelf. U.S. Dept. Commerce NOAA Final Report, vol. I. 587 p.

U.S. ENVIRONMENTAL PROTECTION AGENCY.
1975. Estuarine pollution control and assessment. Proceeedings of a conference. Vol. I. 381 p.

WALLS, J. G.
1975. Fishes of the northern Gulf of Mexico. T.F.H. Publ., Inc., N.J. 432 p.

WOLLAM, M. B.
1970. Description and distribution of larvae and early juveniles of king mackerel, _S. cavalla_ (Cuvier), and Spanish mackerel, _S. maculatus_ (Mitchill); (Pisces: Scombridae); in the western N. Atl., Fla. Dep. Nat. Resour., Mar. Res. Lab., Tech. Ser., No. 61, 35 p.

YENTSCH, S. C., and J. F. HEBARD.
1957. A gauge for determining plankton volume by the mercury immersion method. Jour. du Conseil, 12(2):184-190.

APPENDIX

Table 1. Station depths and locations in the EPA-Buccaneer oil field ichthyoplankton study.

Station	Study area	Depth (m)	Latitude (N)			Longitude (W)		
			°	'	"	°	'	"
A	Control	15	28	55	54	94	45	30
B	Field	17	28	52	54	94	42	33
C	Field	17	28	51	23	94	41	06
D	Control	17	28	48	40	94	38	30
E	Control	17	28	55	15	94	37	36
F	Field	17	28	52	46	94	41	00
G	Field	17	28	51	30	94	42	42
H	Control	17	28	49	00	94	46	05

Table 2 . Station depths and locations in the MARMAP ichthyoplankton study.

Station	Depth (m)	Latitude (N)			Longitude (W)		
		°	'	"	°	'	"
VII-1	18	29	00	00	94	49	30
VII-2[1]	17	28	48	40	94	38	30
VII-3	31	28	37	30	94	28	00
VII-4	42	28	25	50	94	17	30
VII-5	57	38	14	00	94	06	00
VII-6	64	28	02	00	93	56	00
VI-1	18	28	44	00	95	18	00
VI-2	29	28	32	30	95	07	00
VI-3	38	28	20	45	94	56	45
VI-4	52	28	09	15	94	46	00
VI-5	92	27	57	00	94	35	00
V-1	18	28	30	00	95	49	00
V-2	29	28	18	30	95	38	00
V-3	48	28	07	00	95	27	30
V-4	91	27	54	30	95	16	00

[1] Same as EPA station "D".

Table 3. EPA ichthyoplankton data for first sampling cruise, May 24-25, 1976, by station and time taken from bongo tows.

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
A	0.505	5/24	1845	38.1	201	5,276	9	236
	0.333	5/24	1845	34.7	233	6,715	6	173
B*	0.505	5/24	1950	24.1	383	15,892	10	415
	0.333	5/24	1950	20.7	405	19,565	10	483
C*	0.505	5/24	2100	32.4	664	20,494	69	2,130
	0.333	5/24	2100	28.6	829	28,986	62	2,168
D	0.505	5/24	2210	33.9	223	6,578	65	1,917
	0.333	5/24	2210	31.4	231	7,357	76	2,420
E	0.505	5/25	1115	9.1	53	5,824	3	330
	0.333	5/25	1115	8.5	59	6,941	1	118
F*	0.505	5/25	1200	31.0	196	6,323	13	419
	0.333	5/25	1200	29.3	210	7,167	17	580
G*	0.505	5/25	1300	27.6	226	8,188	15	543
	0.333	5/25	1300	26.0	231	8,885	15	577
H	0.505	5/25	1400	25.3	154	6,087	4	158
	0.333	5/25	1400	23.4	326	13,932	4	171

*Field stations.

Table 4. EPA ichthyoplankton data for second sampling cruise, August 16-17, 1976, by station and time taken from bongo tows.

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
A	0.505	8/16	1930	18.8	4	213	12	638
	0.333	8/16	1930	17.2	31	1,802	60	3,488
B*	0.505	8/16	2200	24.8	100	4,032	57	2,298
	0.333	8/16	2200	22.4	122	5,446	59	2,634
C*	0.505	8/17	1814	26.4	39	1,477	27	1,023
	0.333	8/17	1814	25.1	54	2,151	65	2,590
D	0.505	8/17	1935	31.1	4	129	215	6,913
	0.333	8/17	1935	28.1	6	214	339	12,064
E	0.505	8/17	1640	27.4	123	4,489	20	730
	0.333	8/17	1640	26.1	122	4,674	21	805
F*	0.505	8/17	1505	39.2	45	1,148	73	1,862
	0.333	8/17	1505	36.3	152	4,187	187	5,152
G*	0.505	8/17	1330	34.9	99	2,837	52	1,490
	0.333	8/17	1330	29.3	143	4,881	61	2,082
H	0.505	8/17	1200	22.2	90	4,054	13	586
	0.333	8/17	1200	16.6	302	18,193	15	903

*Field stations.

Table 5. EPA ichthyoplankton data for third sampling cruise, December 3-4, 1976, by station and time taken from bongo tows.

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
A	.505	12/4	1255	24.8	4	161	1	40
	.333	12/4	1255	24.5	1	41	0	0
B*	.505	12/4	1137	23.6	109	4,619	5	212
	.333	12/4	1137	25.4	7	276	12	472
C*	.505	12/4	1042	25.9	7	270	7	270
	.333	12/4	1042	28.5	6	211	23	807
D	.505	12/4	0922	38.7	104	2,687	3	78
	.333	12/4	0922	40.7	69	1,695	17	418
E	.505	12/3	2154	34.6	2	58	9	260
	.333	12/3	2154	36.4	2	55	33	907
F*	.505	12/3	2042	39.9	11	276	39	977
	.333	12/3	2042	39.4	10	254	63	1,599
G*	.505	12/3	1959	32.0	17	531	15	469
	.333	12/3	1959	32.7	7	214	52	1,590
H	.505	12/3	1820	30.3	14	462	8	264
	.333	12/3	1820	32.5	16	492	31	954

*Field stations.

Table 6. EPA ichthyoplankton data for fourth sampling cruise, February 19, 1977, by station and time taken from bongo tows.

Station	Mesh size (mm)	Date (1977)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
A	.505	2/19	1110	43.7	2	46	5	114
	.333		1110	44.4	1	23	1	23
B*	.505	2/19	1212	52.4	8	153	3	57
	.333		1212	53.0	13	245	11	208
C*	.505	2/19	1315	34.7	4	115	1	29
	.333		1315	34.5	2	58	10	290
D	.505	2/19	1845	40.2	9	224	9	224
	.333		1845	42.7	8	188	6	141
E	.505	2/19	1405	32.3	5	155	5	155
	.333		1405	32.5	3	92	4	123
F*	.505	2/19	1510	46.8	6	128	6	128
	.333		1510	47.1	7	149	8	170
G*	.505	2/19	1605	55.0	11	200	2	36
	.333		1605	54.4	4	74	4	74
H	.505	2/19	1723	48.7	10	205	24	493
	.333		1723	51.7	10	193	9	174

*Field stations.

Table 6. (Continued)

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
V-2	.505	5/29	1200	55.2	1,428	25,870	63	1,141
	.333	5/29	1200	49.1	1,269	25,845	102	2,077
V-3	.505	5/29	1455	50.1	109	2,176	65	1,297
	.333	5/29	1455	51.3	174	3,392	156	3,041
V-4	.505	5/29	1835	167.9	46	274	212	1,263
	.333	5/29	1835	162.3	48	296	308	1,898

Table 7. MARMAP ichthyoplankton data for first sampling cruise, May 24-29, 1976, by station and time taken from bongo net tows.

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
VII-1	.505	5/24	1700	19.4	9	464	0	0
	.333	5/24	1700	16.4	17	1,037	2	122
VII-2	.505	5/24	2210	33.9	223	6,578	65	1,917
	.333	5/24	2210	31.4	231	7,357	76	2,420
VII-3	.505	5/25	1750	37.4	267	7,139	64	1,711
	.333	5/25	1750	35.1	242	6,895	89	2,536
VII-4	.505	5/25	2125	45.5	76	1,670	89	1,956
	.333	5/25	2125	45.0	99	2,200	128	2,844
VI-1	.505	5/27	2250	33.9	27	796	19	560
	.333	5/27	2250	27.5	27	982	30	1,091
VI-2	.505	5/27	1800	53.1	313	5,895	26	490
	.333	5/27	1800	47.9	338	7,056	124	2,589
VI-3	.505	5/27	1420	61.8	194	3,139	35	566
	.333	5/27	1420	58.7	194	3,305	44	750
VI-4	.505	5/27	1110	85.6	83	970	30	350
	.333	5/27	1110	83.3	75	900	53	636
V-1	.505	5/29	0900	34.5	129	3,739	30	870
	.333	5/29	0900	29.5	129	4,373	43	1,458

Table 7. (Continued)

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
VI-4	.505	8/19	1500	75.2	80	1,064	149	1,981
	.333	8/19	1500	74.3	15	202	202	2,719
VI-5	.505	8/19	1145	155.5	17	109	146	939
	.333	8/19	1145	151.2	22	146	209	1,382
V-1	.505	8/20	1835	29.6	70	2,365	19	642
	.333	8/20	1835	27.5	53	1,927	94	3,418
V-2	.505	8/20	1550	37.5	168	4,480	34	907
	.333	8/20	1550	35.9	213	5,933	184	5,125
V-3	.505	8/20	1250	80.8	69	854	102	1,262
	.333	8/20	1250	76.8	51	664	190	2,474
V-4	.505	8/19	2330	179.7	48	267	477	2,654
	.333	8/19	2330	178.4	41	230	799	4,479

Table 8. MARMAP ichthyoplankton data for second sampling cruise, August 16-21, 1976, by station and time taken from bongo net tows.

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
VII-1	.505	8/16	1630	22.6	53	2,345	39	1,726
	.333	8/16	1630	19.6	64	3,265	59	3,010
VII-2	.505	8/17	1935	31.1	4	129	215	6,913
	.333	8/17	1935	28.1	6	214	339	12,064
VII-3	.505	8/17	2238	41.0	109	2,659	72	1,756
	.333	8/17	2238	39.1	114	2,916	93	2,379
VII-4	.505	8/18	1345	66.8	188	2,814	97	1,452
	.333	8/18	1345	65.5	338	5,160	220	3,359
VII-5	.505	8/18	1700	74.2	59	795	101	1,361
	.333	8/18	1700	73.6	96	1,304	170	2,310
VII-6	.505	8/18	2100	115.6	9	78	200	1,730
	.333	8/18	2100	115.3	11	95	329	2,853
VI-1	.505	8/21	0005	25.4	303	11,929	91	3,583
	.333	8/21	0005	23.6	430	18,220	259	10,975
VI-2	.505	8/21	0315	54.7	183	3,346	85	1,554
	.333	8/21	0315	53.0	353	6,660	187	3,528
VI-3	.505	8/19	1807	55.3	70	1,266	47	850
	.333	8/19	1807	53.2	87	1,635	118	2,218

Table 9. MARMAP ichthyoplankton data for third sampling cruise, November 30-December 4, 1976, by station and time taken from bongo net tows.

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
VII-1	.505	12/4	1417	31.8	0	0	6	189
	.333	12/4	1417	32.6	0	0	5	153
VII-2	.505	12/4	0922	38.7	104	2,687	3	78
	.333	12/4	0922	40.7	69	1,695	17	418
VII-3	.505	11/30	2020	40.3	45	1,117	56	1,390
	.333	11/30	2020	40.7	48	1,179	81	1,990
VII-4	.505	12/1	0005	77.4	71	917	49	633
	.333	12/1	0005	78.3	60	766	143	1,826
VII-5	.505	12/1	0310	83.8	56	668	38	454
	.333	12/1	0310	84.1	39	464	95	1,130
VII-6	.505	12/1	0725	129.1	45	349	23	178
	.333	12/1	0725	128.4	42	327	104	810
VI-1	.505	12/3	1032	29.0	1	34	2	69
	.333	12/3	1032	28.0	1	36	11	393
VI-2	.505	12/3	1315	52.3	63	1,205	103	1,969
	.333	12/3	1315	56.5	54	956	287	5,080
VI-3	.505	12/1	2110	71.2	86	1,208	106	1,489
	.333	12/1	2110	70.8	87	1,229	122	1,723

Table 9. MARMAP ichthyoplankton data for third sampling cruise, November 30-December 4, 1976, by station and time taken from bongo net tows (continued).

Station	Mesh size (mm)	Date (1976)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
VI-4	.505	12/1	1740	94.8	40	422	40	422
	.333	12/1	1740	94.9	36	379	182	1,918
VI-5	.505	12/1	1425	154.3	50	324	61	395
	.333	12/1	1425	157.0	64	408	186	1,185
V-1	.505	12/2	1447	22.5	22	978	11	489
	.333	12/2	1447	22.3	9	404	13	583
V-2	.505	12/2	1145	56.6	88	1,555	58	1,025
	.333	12/2	1145	59.3	138	2,327	250	4,216
V-3	.505	12/2	0825	92.1	136	1,477	62	673
	.333	12/2	0825	84.4	109	1,291	136	1,611
V-4	.505	12/2	0340	167.5	8	48	116	693
	.333	12/2	0340	---*	---	-----	---	-----

*Sample lost during rough weather.

Table 10. MARMAP ichthyoplankton data for fourth sampling cruise, February 18-20, 1977, by station and time taken from bongo net tows.

Station	Mesh size (mm)	Date (1977)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
VII-1	.505	2/19	1005	57.0	8	140	4	70
	.333	2/19	1005	57.3	3	52	11	192
VII-2	.505	2/19	1845	40.2	9	224	9	224
	.333	2/19	1845	42.7	8	187	6	141
VII-3	.505	2/19	2040	73.7	13	176	40	543
	.333	2/19	2040	74.8	19	254	37	495
VII-4	.505	2/19	2240	92.2	647	7,017	237	2,570
	.333	2/19	2240	91.8	707	7,702	222	2,418
VII-5	.505	2/20	0032	110.8	68	614	883	7,969
	.333	2/20	0032	111.4	79	709	1,100	9,874
VII-6	.505*	2/20	0300	144.6	-	-	-	-
	.333	2/20	0300	140.1	168	1,199	452	3,226
VI-1	.505	2/19	0615	54.1	1	18	1	18
	.333	2/19	0615	55.0	0	0	2	36
VI-2	.505	2/19	0320	83.0	6	72	50	602
	.333	2/19	0320	83.0	5	60	65	783
VI-3	.505	2/19	0040	98.7	241	2,442	245	2,482
	.333	2/19	0040	98.7	185	1,874	321	3,252

Table 10. (Continued)

Station	Mesh size (mm)	Date (1977)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
VI-4	.505	2/18	2210	165.9	319	1,923	349	2,104
	.333	2/18	2210	115.7	195	1,685	350	3,025
VI-5	.505	2/18	1955	231.6	369	1,593	378	1,632
	.333	2/18	1955	226.0	271	1,199	461	2,040
V-1	.505	2/18	0040	40.1	0	0	4	100
	.333	2/18	0040	36.1	0	0	1	28
V-2	.505	2/18	0315	60.4	15	248	41	679
	.333	2/18	0315	91.4	26	285	66	722
V-3	.505	2/18	0615	126.5	379	2,996	454	3,589
	.333	2/18	0615	124.4	406	3,264	577	4,638
V-4	.505	2/18	0850	178.2	62	348	99	556
	.333	2/18	0850	177.0	54	305	203	1,147

*505 μ sample partially lost.

Table 11. Displacement volumes in milliliters of plankton from EPA field and control stations by gear type for 1976 and 1977.

	May			August			December			February		
Station	Bongo .505mm	Bongo .333mm	Neuston .505mm	Bongo .505mm	Bongo .333mm	Neuston .505mm	Bongo .505mm	Bongo .333mm	Neuston .505mm	Bongo .505mm	Bongo .333mm	Neuston .505mm
A	2.3	4.8	17.4	1.9	3.9	295.6	0.3	1.5	5.9	9.7	10.6	72.1
B*	4.2	7.4	22.4	3.6	5.7	13.9	6.4	4.4	3.3	20.2	28.8	51.8
C*	9.7	13.0	27.3	4.5	6.3	13.7	0.5	2.4	6.3	7.5	9.7	55.0
D	16.0	14.0	56.6	3.4	6.4	440.1	0.4	1.6	4.2	11.0	15.4	419.9
E	3.5	1.7	1.4	2.1	1.9	9.1	0.4	4.9	9.3	9.6	10.8	95.1
F*	10.3	11.3	14.8	5.2	5.7	3.1	2.0	5.8	7.1	10.2	8.9	199.8
G*	18.5	11.2	6.2	0.3	1.0	2.1	0.9	4.3	5.6	11.0	14.1	114.7
H	2.2	4.6	5.6	1.4	0.7	0.2	0.2	3.5	15.7	8.4	11.7	128.2

*Field stations

Table 12. Species list for first cruise, May 24-25, 1976, showing fish larvae in descending order of abundance for all gear types.

Family	Genus	Species	No.	Percent of total catch
GOBIIDAE	---	---	99	13.1
ENGRAULIDAE	*Anchoa*	sp.	98	13.0
TETRAODONTIDAE	*Sphoeroides*	sp.	63	8.3
SERRANIDAE	*Diplectrum*	sp.	56	7.4
BOTHIDAE	---	---	52	6.9
ENGRAULIDAE	---	---	38	5.0
CYNOGLOSSIDAE	*Symphurus*	sp.	22	2.9
BOTHIDAE	*Syacium*	*gunteri*	19	2.5
CARANGIDAE	*Decapterus*	*punctatus*	17	2.3
CLUPEIDAE	*Sardinella*	sp.	15	2.0
BOTHIDAE	*Syacium*	sp.	13	1.7
CARANGIDAE	*Chloroscombrus*	*chrysurus*	13	1.7
OPHIDIIDAE	---	---	13	1.7
MICRODESMIDAE	*Microdesmus*	sp.	12	1.6
CARANGIDAE	---	---	8	1.1
BLENNIIDAE	*Hypsoblennius*	sp.	7	0.9
SCORPAENIDAE	*Scorpaena*	sp.	5	0.7
SERRANIDAE	*Serraniculus*	*pumilio*	5	0.7
EPHIPPIDAE	*Chaetodipterus*	*faber*	4	0.5
POMADASYIDAE	---	---	4	0.5
SCOMBRIDAE	*Euthynnus*	*alletteratus*	4	0.5
CARANGIDAE	*Trachurus*	*lathami*	3	0.4
CLUPEIDAE	---	---	3	0.4
LABRIDAE	---	---	3	0.4
SCOMBRIDAE	*Scomberomorus*	*cavalla*	3	0.4
BLENNIIDAE	---	---	2	0.3
ENGRAULIDAE	*Engraulis*	*eurystole*	2	0.3
SCIAENIDAE	*Leiostomus*	*xanthurus*	2	0.3
SCIAENIDAE	*Menticirrhus*	sp.	2	0.3
SYNGNATHIDAE	*Syngnathus*	*louisianae*	2	0.3
TETRAODONTIDAE	---	---	2	0.3
LUTJANIDAE	---	---	2	0.3
TRIGLIDAE	*Prionotus*	sp.	2	0.3
BALISTIDAE	*Monacanthus*	*hispidus*	1	0.1
CLUPEIDAE	*Harengula*	*jaguana*	1	0.1
CONGRIDAE	---	---	1	0.1
EXOCOETIDAE	---	---	1	0.1
MULLIDAE	---	---	1	0.1
OPHICHTHIDAE	---	---	1	0.1
SCIAENIDAE	*Cynoscion*	sp.	1	0.1

Table 12. (Continued)

Family	Genus	Species	No.	Percent of total catch
STROMATEIDAE	*Peprilus*	*alepidotus*	1	0.1
SYNODONTIDAE	*Saurida*	sp.	1	0.1
SYNODONTIDAE	*Synodus*	*foetens*	1	0.1
SYNODONTIDAE	*Synodus*	sp.	1	0.1
UNKNOWN			149	19.7
		Total	755	99.8

Table 13. Species list for second cruise, August 16-17, 1976, showing fish larvae in descending order of abundance for all gear types.

Family	Genus	Species	No.	Percent of total catch
ENGRAULIDAE	---	---	897	53.0
CARANGIDAE	---	---	145	8.6
ENGRAULIDAE	*Engraulis*	*eurystole*	96	5.7
CLUPEIDAE	---	---	66	3.9
GOBIIDAE	---	---	57	3.4
SCOMBRIDAE	---	---	35	2.1
CYNOGLOSSIDAE	*Symphurus*	sp.	31	1.8
EXOCOETIDAE	*Parexocoetus*	*brachypterus*	28	1.7
CLUPEIDAE	*Harengula*	*jaguana*	26	1.5
BOTHIDAE	*Syacium*	sp.	18	1.1
EXOCOETIDAE	---	---	18	1.1
ENGRAULIDAE	*Anchoa*	sp.	17	1.0
SCOMBRIDAE	*Euthynnus*	*alletteratus*	15	0.9
CARANGIDAE	*Decapterus*	*punctatus*	14	0.8
SCIAENIDAE	---	---	12	0.7
TETRAODONTIDAE	*Sphoeroides*	sp.	10	0.6
CLUPEIDAE	*Opisthonema*	*oglinum*	9	0.5
BOTHIDAE	*Syacium*	*gunteri*	8	0.5
SCOMBRIDAE	*Scomberomorus*	*maculatus*	8	0.5
SCOMBRIDAE	*Scomberomorus*	*cavalla*	7	0.4
BOTHIDAE	---	---	6	0.4
TRIGLIDAE	*Prionotus*	sp.	4	0.2
SERRANIDAE	*Diplectrum*	sp.	3	0.2
CARANGIDAE	*Chloroscombrus*	*chrysurus*	2	0.1
MICRODESMIDAE	*Microdesmus*	sp.	2	0.1
OPHIDIIDAE	---	---	2	0.1
SPHYRAENIDAE	*Sphyraena*	sp.	2	0.1
CLUPEIDAE	*Sardinella*	sp.	1	0.1
EXOCOETIDAE	*Cypselurus*	sp.	1	0.1
GERREIDAE	---	---	1	0.1
OGCOCEPHALIDAE	---	---	1	0.1
EPHIPPIDAE	*Chaetodipterus*	*faber*	1	0.1
MURAENIDAE	*Gymnothorax*	sp.	1	0.1
SCIAENIDAE	*Menticirrhus*	sp.	1	0.1
SCIAENIDAE	*Bairdiella*	*chrysura*	1	0.1
SERRANIDAE	*Serraniculus*	*pumilio*	1	0.1
SYNODONTIDAE	*Saurida*	sp.	1	0.1
UNKNOWN			144	8.5
		Total	1,692	100.5

Table 14. Species list for third cruise, December 3-4, 1976, showing fish larvae in descending order of abundance for all gear types.

Family	Genus	Species	No.	Percent of total catch
GOBIIDAE	---	---	105	26.3
SCIAENIDAE	---	---	63	15.6
BOTHIDAE	*Paralichthys*	sp.	57	14.3
SCIAENIDAE	*Leiostomus*	*xanthurus*	40	10.0
SCIAENIDAE	*Micropogon*	*undulatus*	35	8.8
BOTHIDAE	---	---	23	5.8
CLUPEIDAE	---	---	8	2.0
CLUPEIDAE	*Brevoortia*	sp.	5	1.3
ENGRAULIDAE	*Anchoa*	sp.	5	1.3
ENGRAULIDAE	---	---	4	1.0
BREGMACEROTIDAE	*Bregmaceros*	*atlanticus*	3	0.8
ENGRAULIDAE	*Engraulis*	*eurystole*	3	0.8
SYNODONTIDAE	*Saurida*	sp.	3	0.8
SPARIDAE	---	---	2	0.5
STROMATEIDAE	*Peprilus*	*burti*	2	0.5
GADIDAE	*Urophycis*	sp.	1	0.3
TRIGLIDAE	*Prionotus*	sp.	1	0.3
UNKNOWN			40	10.0
		Total	400	100.4

Table 15. Species list for fourth cruise, February 19, 1977, showing fish larvae in descending order of abundance for all gear types.

Family	Genus	Species	No.	Percent of total catch
CLUPEIDAE	*Brevoortia*	sp.	74	37.4
GADIDAE	*Urophycis*	*floridanus*	31	15.7
CLUPEIDAE	---	---	24	12.1
STROMATEIDAE	*Peprilus*	*burti*	10	5.1
BOTHIDAE	---	---	6	3.0
BOTHIDAE	*Paralichthys*	sp.	5	2.5
SPARIDAE	*Lagodon*	*rhomboides*	5	2.5
TRIGLIDAE	*Prionotus*	sp.	5	2.5
SCIAENIDAE	*Micropogon*	*undulatus*	4	2.0
SERRANIDAE	---	---	4	2.0
GOBIIDAE	---	---	3	1.5
BREGMACEROTIDAE	*Bregmaceros*	*atlanticus*	2	1.0
SPARIDAE	---	---	2	1.0
CARANGIDAE	*Trachurus*	*lathami*	1	0.5
MUGILIDAE	*Mugil*	*cephalus*	1	0.5
MYCTOPHIDAE	*Diaphus*	sp.	1	0.5
MYCTOPHIDAE	*Lampanyctus*	sp.	1	0.5
MYCTOPHIDAE	*Notoscopelus*	*resplendens*	1	0.5
SCIAENIDAE	*Leiostomus*	*xanthurus*	1	0.5
UNKNOWN			17	8.6
		Total	198	99.9

Table 16. Species list of larvae taken in bongo and neuston samples from the EPA field and control stations from May 1976 to February 1977.

Family	Genus	Species
BALISTIDAE (triggerfishes and filefishes)	Monacanthus	hispidus
BLENNIIDAE (combtooth blennies)	Hypsoblennius	sp.
BOTHIDAE (lefteye flounders)	Paralichthys	sp.
	Syacium	gunteri
	Syacium	sp.
BREGMACEROTIDAE (codlets)	Bregmaceros	atlanticus
CARANGIDAE (jacks and pompanos)	Chloroscombrus	chrysurus
	Decapterus	punctatus
	Trachurus	lathami
CLUPEIDAE (herrings)	Brevoortia	sp.
	Harengula	jaguana
	Opisthonema	oglinum
	Sardinella	sp.
CONGRIDAE (conger eels)	--	--
CYNOGLOSSIDAE (tonguefishes)	Symphurus	sp.
ENGRAULIDAE (anchovies)	Anchoa	sp.
	Engraulis	eurystole
EPHIPPIDAE (spadefishes)	Chaetodipterus	faber
EXOCOETIDAE (flyingfishes and halfbeaks)	Cypselurus	sp.
	Parexocoetus	brachypterus
GADIDAE (codfishes)	Urophycis	floridanus
	Urophycis	sp.

Table 16. (Continued)

Family	Genus	Species
SCOMBRIDAE (mackerels and tunas)	*Euthynnus*	*alletteratus*
	Scomberomorus	*cavalla*
	Scomberomorus	*maculatus*
SCORPAENIDAE (scorpionfishes)	*Scorpaena*	sp.
SERRANIDAE (sea basses)	*Diplectrum*	sp.
	Serraniculus	*pumilio*
SPARIDAE (porgies)	*Lagodon*	*rhomboides*
SPHYRAENIDAE (barracudas)	*Sphyraena*	sp.
STROMATEIDAE (butterfishes)	*Peprilus*	*alepidotus*
	Peprilus	*burti*
SYNGNATHIDAE (pipefishes and seahorses)	*Syngnathus*	*louisianae*
SYNODONTIDAE (lizardfishes)	*Saurida*	sp.
	Synodus	*foetens*
	Synodus	sp.
TETRAODONTIDAE (puffers)	*Sphoeroides*	sp.
TRIGLIDAE (searobins)	*Prionotus*	sp.

Table 16. (Continued)

Family	Genus	Species
GERREIDAE (mojarras)	--	--
GOBIIDAE (gobies)	--	--
LABRIDAE (wrasses)	--	--
LUTJANIDAE (snappers)	--	--
MICRODESMIDAE (wormfishes)	*Microdesmus*	sp.
MUGILIDAE (mullets)	*Mugil*	*cephalus*
MULLIDAE (goatfishes)	--	--
MURAENIDAE (morays)	*Gymnothorax*	sp.
MYCTOPHIDAE (lanternfishes)	*Diaphus*	sp.
	Lampanyctus	sp.
	Notoscopelus	*resplendens*
OGCOCEPHALIDAE (batfishes)	--	--
OPHICHTHIDAE (snake eels)	--	--
OPHIDIIDAE (cusk-eels and brotulas)	--	--
POMADASYIDAE (grunts)	--	--
SCIAENIDAE (drums)	*Bairdiella*	*chrysura*
	Cynoscion	sp.
	Leiostomus	*xanthurus*
	Menticirrhus	sp.
	Micropogon	*undulatus*

Table 17. Diversity of larval fishes taken in bongo samples at Buccaneer oil field and control stations from May 1976 to February 1977.

	Cruise 1 (May 1976)			Cruise 2 (Aug. 1976)			Cruise 3 (Dec. 1976)			Cruise 4 (Feb. 1977)			All cruises		
Stations	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.
Four field: (B,C,F,G)	18	16	8	15	15	8	7	8	4	10	10	5	25	33	20
Four control: (A,D,E,H)	17	12	4	12	8	6	9	6	4	10	8	5	26	24	13
Total of field and control	22	17	8	18	17	9	10	10	5	11	11	6	31	35	21

Table 18. Dominant larval families in descending order of abundance by gear type for all EPA stations during first cruise, May 24 and 25, 1976.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Engraulidae	23.4	Gobiidae	24.6	Engraulidae	13.0
Gobiidae	14.9	Engraulidae	21.5	Tetraodontidae	11.9
Bothidae	12.8	Bothidae	13.6	Bothidae	9.2
Tetraodontidae	7.5	Cynoglossidae	5.8	Gobiidae	6.5
Carangidae	6.9	Carangidae	4.7	Carangidae	4.9
Ophidiidae	4.3	Tetraodontidae	3.7	Clupeidae	4.6
Cynoglossidae	3.7	Microdesmidae	2.6	Blenniidae	2.2
Microdesmidae	2.7	Ophidiidae	2.1	Scombridae	1.9
Clupeidae	1.1	Scorpaenidae	1.0	Sciaenidae	1.4
Pomadasyidae	1.1			Cynoglossidae	1.1
TOTAL	78.4		79.6		56.7

Table 19. Dominant larval families in descending order of abundance by gear type for all EPA stations during second cruise, August 16 and 17, 1976.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Engraulidae	66.7	Engraulidae	61.3	Engraulidae	48.4
Carangidae	11.1	Carangidae	7.7	Exocoetidae	11.3
Scombridae	5.8	Clupeidae	5.4	Carangidae	11.3
Clupeidae	3.0	Gobiidae	4.5	Clupeidae	9.8
Gobiidae	2.8	Scombridae	3.4	Scombridae	3.6
Bothidae	2.1	Cynoglossidae	2.2	Sciaenidae	2.6
Cynoglossidae	1.9	Bothidae	2.2	Tetraodontidae	2.2
Sciaenidae	1.7	Microdesmidae	0.5	Gobiidae	1.9
Serranidae	0.4	Serranidae	0.3	Bothidae	1.0
				Cynoglossidae	1.0
				Triglidae	0.7
TOTAL	95.5		87.5		93.8

Table 20. Dominant larval families in descending order of abundance by gear type for all EPA stations during third cruise, December 3 and 4, 1976.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Sciaenidae	47.1	Bothidae	29.2	Sciaenidae	50.0
Gobiidae	23.0	Gobiidae	26.6	Gobiidae	28.0
Bothidae	9.2	Sciaenidae	24.0	Clupeidae	4.9
Engraulidae	8.1	Clupeidae	2.2	Bothidae	4.9
Clupeidae	4.6	Synodontidae	1.3	Engraulidae	3.7
Triglidae	1.2	Stromateidae	0.9	Bregmacerotidae	1.2
Bregmacerotidae	1.2	Engraulidae	0.9	Gadidae	1.2
		Triglidae	0.4	Sparidae	1.2
		Bregmacerotidae	0.4		
		Sparidae	0.4		
TOTAL	94.4		86.3		95.1

Table 21. Dominant larval families in descending order of abundance by gear type for all EPA stations during fourth cruise, February 19, 1977.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Clupeidae	61.8	Clupeidae	28.3	Clupeidae	54.4
Sparidae	12.7	Bothidae	9.4	Gobiidae	34.4
Bothidae	5.5	Stromateidae	9.4	Bothidae	3.3
Stromateidae	5.5	Serranidae	5.7	Triglidae	3.3
Sciaenidae	3.6	Myctophidae	5.7	Stromateidae	2.2
Gobiidae	1.8	Bregmacerotidae	3.8	Mugilidae	1.1
Triglidae	1.8	Gobiidae	3.8	Sciaenidae	1.1
		Sciaenidae	1.9		
		Sparidae	1.9		
		Triglidae	1.9		
		Carangidae	1.9		
TOTAL	92.7		73.7		99.8

Table 22. Dominant larval families in descending order of abundance by gear type for all EPA stations and cruises from May 1976 to February 1977.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Engraulidae	45.5	Engraulidae	42.0	Engraulidae	26.8
Carangidae	8.1	Gobiidae	11.5	Clupeidae	11.8
Gobiidae	7.8	Bothidae	9.1	Carangidae	6.9
Clupeidae	6.8	Carangidae	5.6	Sciaenidae	6.0
Sciaenidae	5.8	Clupeidae	5.0	Gobiidae	5.7
Bothidae	5.6	Sciaenidae	4.5	Tetraodontidae	5.5
Scombridae	3.5	Cynoglossidae	2.3	Exocoetidae	4.9
Serranidae	2.5	Scombridae	2.1	Bothidae	4.7
Cynoglossidae	2.0	Serranidae	1.6	Serranidae	3.0
Tetraodontidae	1.8	Stromateidae	0.6	Scombridae	1.8
		Tetraodontidae	0.6		
TOTAL	89.4		84.9		77.1

Table 23. Abundance, size and occurrence of larval fishes for the top ten families at the Buccaneer oil field stations from May 1976 to February 1977 taken in bongo nets.

Taxon	Size range (mm)	Mean size (mm)	Total number	Per cent of total catch	Abundance in 1,000/m^3 May	Aug	Dec	Feb
ENGRAULIDAE	2.1-11.5	4.4	271	25.7	68	1,065	8	0
Anchoa sp.	7.0-20.2	12.2	43	4.1	168	13	12	0
Engraulis eurystole	5.5-14.1	7.5	34	3.2	0	130	12	0
GOBIIDAE	1.5-11.0	4.3	134	12.7	187	155	218	5
BOTHIDAE	1.8-10.0	5.4	34	3.2	82	4	57	3
Paralichthys sp.	2.1- 9.4	2.7	47	4.5	0	0	178	8
Syacium gunteri	5.3- 8.6	6.9	18	1.7	55	25	0	0
Syacium sp.	1.4- 8.6	3.0	15	1.4	14	50	0	0
CARANGIDAE	1.7- 5.5	2.8	63	6.0	5	281	0	0
Chloroscombrus chrysurus	4.0- 8.0	5.2	8	0.8	36	0	0	0
Decapterus punctatus	2.3- 6.0	3.8	8	0.8	14	21	0	0
SCIAENIDAE	2.3- 4.1	3.0	52	4.9	0	8	206	0
Bairdiella chrysura	2.0- 2.0	2.0	1	0.1	0	4	0	0
Leiostomus xanthurus	2.8- 7.3	4.1	14	1.3	0	0	57	0
Micropogon undulatus	2.7- 9.5	4.0	11	1.0	0	0	9	2
CLUPEIDAE	2.7- 7.6	4.5	32	3.0	0	96	12	16
Brevoortia sp.	8.3-18.2	11.9	8	0.8	0	0	8	16
Harengula jaguana	9.6- 9.6	9.6	1	0.1	5	0	0	0
Opisthonema oglinum	6.8- 7.7	7.2	3	0.3	0	13	0	0
Sardinella sp.	18.0-18.0	18.0	1	0.1	5	0	0	0
SCOMBRIDAE	1.7- 4.6	3.0	19	1.8	0	77	0	0
Euthynnus alletteratus	3.7- 7.3	5.3	12	1.1	0	50	0	0
Scomberomorus cavalla	3.1- 3.1	3.1	2	0.2	0	8	0	0
Scomberomorus maculatus	2.7- 3.8	3.3	4	0.4	0	17	0	0
CYNOGLOSSIDAE								
Symphurus sp.	1.9-16.0	6.0	18	1.7	55	25	0	0
SERRANIDAE	3.3- 4.7	4.0	3	0.3	0	13	0	0
Diplectrum sp.	1.7-11.0	4.7	11	1.0	36	13	0	0
Serraniculus pumilio	3.5- 3.5	3.5	1	0.1	5	0	0	0
TETRAODONTIDAE								
Sphoeroides sp.	4.0- 6.1	5.0	13	1.2	55	4	0	0

Table 24. Abundance, size and occurrence of larval fishes for the top ten families at the EPA control stations from May 1976 to February 1977 taken in bongo nets.

Taxon	Size range (mm)	Mean size (mm)	Total number	Per cent of total catch	Abundance in 1,000/m^3			
					May	Aug	Dec	Feb
ENGRAULIDAE	2.1-18.0	5.0	474	46.1	44	2,475	4	0
Anchoa sp.	7.0-20.2	12.1	26	2.5	117	11	0	0
Engraulis eurystole	4.8-11.0	6.6	54	5.3	0	288	0	0
GOBIIDAE	1.5- 9.6	4.1	75	7.3	166	64	107	3
CLUPEIDAE	2.1- 8.5	4.4	43	4.2	0	171	15	21
Brevoortia sp.	8.1-19.0	14.3	30	2.9	0	0	0	89
CARANGIDAE	1.5- 6.2	2.5	41	4.0	10	208	0	0
Chloroscombrus chrysurus	3.3- 8.9	5.5	4	0.4	20	0	0	0
Decapterus punctatus	2.7- 6.0	4.4	7	0.7	20	16	0	0
Trachurus lathami	3.0- 3.0	3.0	1	0.1	0	0	0	3
BOTHIDAE	2.6-13.7	5.8	13	1.3	20	5	23	6
Paralichthys sp.	2.1- 7.8	3.3	14	1.4	0	0	46	6
Syacium gunteri	6.4- 8.5	7.3	4	0.4	10	11	0	0
Syacium sp.	1.6- 7.7	4.1	16	1.6	49	32	0	0
CYNOGLOSSIDAE								
Symphurus sp.	1.6-15.2	3.8	27	2.6	29	112	0	0
SCIAENIDAE	2.1- 3.9	2.9	9	0.9	0	5	30	0
Leiostomus xanthurus	2.6- 6.8	3.9	11	1.1	0	0	42	0
Micropogon undulatus	3.0- 8.1	5.2	6	0.6	0	0	15	6
SERRANIDAE	4.1- 4.1	4.1	1	0.1	0	0	0	3
Diplectrum sp.	2.1- 7.9	4.0	20	2.0	98	0	0	0
Serraniculus pumilio	3.2- 6.0	4.7	4	0.4	15	5	0	0
SCOMBRIDAE	1.8- 3.8	2.6	12	1.2	0	64	0	0
Scomberomorus cavalla	3.9- 4.3	4.1	2	0.2	0	11	0	0
Scomberomorus maculatus	2.2- 2.8	2.6	4	0.4	0	21	0	0
TETRAODONTIDAE								
Sphoeroides sp.	3.3- 9.1	6.6	9	0.9	44	0	0	0

Table 25. Relative abundance of larval fishes for the top ten families collected at all EPA stations from May 1976 to February 1977 in neuston tows.

Taxon	No.	Percent of total catch	No. in family	Percent of total catch
ENGRAULIDAE	194	20.4	258	27.1
Anchoa sp.	51	5.3		
Engraulis eurystole	13	1.4		
CLUPEIDAE	26	2.7	114	12.0
Brevoortia sp.	41	4.3		
Harengula jaguana	26	2.7		
Opisthonema oglinum	6	0.6		
Sardinella sp.	15	1.6		
CARANGIDAE	40	4.2	66	6.9
Chloroscombrus chrysurus	7	0.7		
Decapterus punctatus	16	1.7		
Trachurus lathami	3	0.3		
SCIAENIDAE	14	1.5	58	6.1
Cynoscion sp.	1	0.1		
Leiostomus xanthurus	18	1.9		
Menticirrhus sp.	3	0.3		
Micropogon undulatus	22	2.3		
GOBIIDAE	55	5.8	55	5.8
TETRAODONTIDAE			53	5.6
Sphoeroides sp.	53	5.6		
BOTHIDAE	42	4.4	48	5.0
Paralichthys sp.	1	0.1		
Syacium gunteri	5	0.5		
EXOCOETIDAE	18	1.9	47	4.9
Cypselurus sp.	1	0.1		
Parexocoetus brachypterus	28	2.9		
GADIDAE			32	3.4
Urophycis floridanus	31	3.3		
Urophycis sp.	1	0.1		
SERRANIDAE			29	3.0
Diplectrum sp.	28	2.9		
Serraniculus pumilio	1	0.1		

Table 26. Relative abundance of larval fishes for the top ten families collected at all EPA stations from May 1976 to February 1977 in bongo tows.

Taxon	No.	Percent of total catch	No. in family	Percent of total catch
ENGRAULIDAE	745	35.8	902	43.3
Anchoa sp.	69	3.3		
Engraulis eurystole	88	4.2		
GOBIIDAE	209	10.0	209	10.0
BOTHIDAE	48	2.3	162	7.8
Paralichthys sp.	61	2.9		
Syacium sp.	31	1.5		
Syacium gunteri	22	1.1		
CARANGIDAE	113	5.4	137	6.6
Chloroscombrus chrysurus	8	0.4		
Decapterus punctatus	15	0.7		
Trachurus lathami	1	0.1		
CLUPEIDAE	75	3.6	118	5.7
Brevoortia sp.	38	1.8		
Harengula jaguana	1	0.1		
Opisthonema oglinum	3	0.1		
Sardinella sp.	1	0.1		
SCIAENIDAE	61	2.9	104	5.0
Bairdiella chrysura	1	0.1		
Leiostomus xanthurus	25	1.2		
Micropogon undulatus	17	0.8		
SCOMBRIDAE	30	1.4	55	2.6
Euthynnus alletteratus	13	0.6		
Scomberomorus cavalla	4	0.2		
Scomberomorus maculatus	8	0.4		
CYNOGLOSSIDAE			45	2.2
Symphurus sp.	45	2.2		
SERRANIDAE	4	0.2	40	1.9
Diplectrum sp.	31	1.5		
Serraniculus pumilio	5	0.2		
TETRAODONTIDAE			22	1.1
Sphoeroides sp.	22	1.1		

Table 27. Larval abundance from 0.505 mm bongo catches for the top ten MARMAP families in transect VII from May 1976 to February 1977.

Taxon	No.	Number per 1,000 m^3	Family totals Number per 1,000 m^3
Clupeidae	366	260	682
Brevoortia sp.	13	9	
Etrumeus teres	556	395	
Harengula jaguana	3	2	
Opisthonema oglinum	23	16	
Engraulidae	308	219	252
Anchoa sp.	9	6	
Engraulis eurystole	38	27	
Sparidae	168	119	120
Lagodon rhomboides	2	1	
Synodontidae	10	7	83
Saurida sp.	57	41	
Saurida brasiliensis	4	3	
Synodus sp.	44	31	
Synodus foetens	1	1	
Bothidae	16	11	72
Bothus sp.	14	10	
Bothus ocellatus	17	12	
Cyclopsetta sp.	1	1	
Paralichthys sp.	2	1	
Syacium sp.	51	36	
Syacium gunteri	1	1	
Gobiidae	101	72	72
Stromateidae	13	9	68
Peprilus sp.	1	1	
Peprilus burti	82	58	
Bregmacerotidae			
Bregmaceros sp.	12	9	66
Bregmaceros atlanticus	80	57	
Carangidae	17	12	46
Chloroscombrus chrysurus	4	3	
Decapterus punctatus	18	13	
Trachurus lathami	26	18	
Serranidae	12	9	44
Centropristis sp.	25	18	
Diplectrum sp.	21	15	
Serraniculus pumilio	3	2	

Table 28. Abundance and occurrence of fish larvae from all bongo samples collected in the control and field areas from May 1976 to February 1977.

Stations	May 1976			August 1976			December 1976			February 1977		
	No.	% of total catch	No./ 1,000m^3	No.	% of total catch	No./ 1,000m^3	No.	% of total catch	No./ 1,000m^3	No.	% of total catch	No./ 1,000m^3
(Control)												
A	15	4.0	206	72	5.6	2,000	1	0.3	20	6	5.6	68
D	141	37.2	2,159	554	43.4	9,358	20	6.3	252	15	13.9	181
E	4	1.1	227	41	3.2	766	42	13.2	591	9	8.3	139
H	8	2.1	164	28	2.2	722	39	12.3	621	33	30.1	329
Totals	168	44.3	822	695	54.5	3,707	102	32.1	762	63	58.3	187
(Field)												
B	20	5.3	446	116	9.1	2,458	17	5.4	347	14	13.0	133
C	131	34.6	2,148	92	7.2	1,786	30	9.4	551	11	10.2	159
F	30	7.9	498	260	20.4	3,444	102	32.1	1,286	14	13.0	149
G	30	7.9	560	113	8.9	1,760	67	21.1	1,036	6	5.6	55
Totals	211	55.7	960	581	45.5	2,437	216	67.9	873	45	41.7	119

Table 29. Abundance and occurrence of fish eggs from all bongo samples collected in the control and field areas from May 1976 to February 1977.

Stations	May 1976			August 1976			December 1976			February 1977		
	No.	% of total catch	No./ 1000m^3	No.	% of total catch	No./ 1000m^3	No.	% of total catch	No./ 1000m^3	No.	% of total catch	No./ 1000m^3
(Control)												
A	434	9.4	5,962	35	2.4	972	5	1.3	10	3	2.9	34
D	454	9.8	6,952	10	0.7	169	173	44.8	2,179	17	16.5	205
E	112	2.4	6,364	245	17.1	4,579	4	1.0	56	8	7.8	123
H	480	10.4	9,856	392	27.3	10,103	30	7.8	478	20	19.4	199
Totals	1,480	32.0	7,241	682	47.5	3,637	212	54.9	808	48	46.6	143
(Field)												
B	788	17.0	17,589	222	15.5	4,703	116	30.0	2,367	21	20.4	199
C	1,493	32.3	24,475	93	6.5	1,806	13	3.4	240	6	5.8	87
F	406	8.8	6,733	197	13.7	2,609	21	5.4	265	13	12.6	14
G	457	9.9	8,526	242	16.9	3,769	24	6.2	371	15	14.6	137
Totals	3,144	68.0	9,834	754	52.6	3,163	174	45.0	703	55	53.4	146

Table 30. Abundance and occurrence of fish eggs from 0.333 mm bongo samples at selected EPA and MARMAP stations from May 1976 to February 1977.

Station	Number per 1,000 m^3			
	May	August	December	February
(MARMAP)				
VII-1	1,037	3,265	0	52
VII-2	7,357	214	1,695	187
VI-1	982	18,220	36	0
V-1	4,373	1,927	404	0
Totals	3,855	5,597	639	58
(EPA)				
B	19,565	5,446	276	245
C	28,986	2,151	211	58
F	7,167	4,187	254	149
G	8,885	4,881	214	74
Totals	16,013	4,164	238	138

Table 31. Temperature and salinity ranges for the ten most abundant families from all larval collections.

Taxon	Temperature1/ Range (°C)	Salinity2/ Range (°/oo)
ENGRAULIDAE	15.3-30.5	25.0-36.3
Anchoa sp.	15.9-29.4	25.0-36.3
Engraulis eurystole	15.9-29.8	26.0-32.8
GOBIIDAE	14.3-30.4	25.0-36.3
CLUPEIDAE	13.7-30.5	26.0-36.7
Brevoortia sp.	13.4-16.5	31.9-36.7
Harengula jaguana	24.5-25.5	25.0-31.5
Opisthonema oglinum	28.5-30.5	29.0-32.8
Sardinella sp.	24.5-26.0	26.0-32.0
BOTHIDAE	13.7-30.5	25.0-36.7
Paralichthys sp.	13.7-17.5	31.9-36.7
Syacium gunteri	24.5-26.0	26.0-32.0
Syacium sp.	24.5-30.5	26.0-32.8
CARANGIDAE	24.5-30.5	26.0-34.0
Chloroscombrus chrysurus	24.5-30.5	25.0-34.0
Decapterus punctatus	24.5-30.5	26.0-34.0
Trachurus lathami	14.0-26.0	25.0-36.3
SCIAENIDAE	15.9-26.2	25.0-35.2
Bairdiella chrysura	---	---
Cynoscion sp.	24.5-25.5	25.0-31.5
Leiostomus xanthurus	14.3-26.0	26.0-36.3
Menticirrhus sp.	24.5-29.4	26.0-32.7
Micropogon undulatus	13.7-17.5	31.9-36.7
TETRAODONTIDAE		
Sphoeroides sp.	24.5-30.4	25.0-32.8
SCOMBRIDAE	29.1-33.1	28.0-30.5
Euthynnus alletteratus	26.0-32.0	24.5-30.4
Scomberomorus cavalla	24.5-29.8	25.0-33.1
Scomberomorus maculatus	28.0-30.4	29.0-33.1
SERRANIDAE	15.2-16.5	36.3-36.3
Diplectrum sp.	24.5-29.8	25.0-32.0
Serraniculus pumilio	24.5-29.3	26.0-33.1
CYNOGLOSSIDAE		
Symphurus sp.	24.5-30.5	25.0-34.0

1/Temperature measurements at field stations in Cruises 3 and 4 were taken by hand thermometer.

2/Salinity measurements were not taken at field stations in Cruises 3 and 4.

Table 32. Distribution of fish larvae taken in bongo and neuston samples from field and control stations by family, genus and species from May 1976 to February 1977.

	EPA stations							
	Control				Field			
Taxon	A	D	E	H	B	C	F	G
BALISTIDAE	x							
Monacanthus hispidus	x							
BLENNIIDAE					x			
Hypsoblennius sp.		x				x		
BOTHIDAE	x	x	x	x	x	x	x	x
Paralichthys sp.			x	x	x	x	x	x
Syacium gunteri		x	x		x	x	x	
Syacium sp.		x	x			x	x	x
BREGMACEROTIDAE								
Bregmaceros atlanticus		x		x		x		x
CARANGIDAE	x	x	x	x	x	x	x	x
Chloroscombrus chrysurus	x	x	x	x		x	x	x
Decapterus punctatus		x	x	x		x	x	x
Trachurus lathami	x		x					
CLUPEIDAE	x	x	x	x	x	x	x	x
Brevoortia sp.	x	x	x	x	x	x	x	
Harengula jaguana					x			
Opisthonema oglinum	x		x			x	x	
Sardinella sp.		x			x	x		
CONGRIDAE					x			
CYNOGLOSSIDAE								
Symphurus sp.	x	x	x	x	x	x	x	x
ENGRAULIDAE	x	x	x	x	x	x	x	x
Anchoa sp.	x	x	x		x	x	x	x
Engraulis eurystole		x			x	x	x	
EPHIPPIDAE								
Chaetodipterus faber	x				x			

Table 32. (Continued)

Taxon	EPA stations							
	Control				Field			
	A	D	E	H	B	C	F	G
EXOCOETIDAE	x	x	x			x	x	x
Cypselurus sp.	x							
Parexocoetus brachypterus	x	x	x			x	x	
GADIDAE								
Urophycis floridanus		x						
Urophycis sp.								x
GERREIDAE	x							
GOBIIDAE	x	x	x	x	x	x	x	x
LABRIDAE		x				x		
LUTJANIDAE		x						
MICRODESMIDAE								
Microdesmus sp.		x			x	x	x	
MUGILIDAE								
Mugil cephalus					x			
MULLIDAE		x						
MURAENIDAE								
Gymnothorax sp.					x			
MYCTOPHIDAE								
Diaphus sp.							x	
Lampanyctus sp.					x			
Notoscopelus resplendens						x		
OGCOCEPHALIDAE			x					
OPHICHTHIDAE	x							
OPHIDIIDAE	x	x	x		x	x		
POMADASYIDAE		x			x	x		

Table 32. (Continued)

Taxon	EPA stations							
	Control				Field			
	A	D	E	H	B	C	F	G
SCIAENIDAE	x		x		x		x	
Bairdiella chrysura					x			
Cynoscion sp.					x			
Leiostomus xanthurus		x	x	x	x	x	x	x
Menticirrhus sp.	x					x		
Micropogon undulatus		x	x	x	x	x	x	x
SCOMBRIDAE	x		x	x	x		x	x
Euthynnus alletteratus		x			x	x	x	x
Scomberomorus cavalla	x	x		x	x	x		
Scomberomorus maculatus	x	x		x		x	x	
SCORPAENIDAE								
Scorpaena sp.		x				x		
SERRANIDAE		x				x	x	
Diplectrum sp.		x			x	x		
Serraniculus pumilio		x		x		x		
SPARIDAE	x	x		x				x
Lagodon rhomboides				x				x
SPHYRAENIDAE								
Sphyraena sp.						x	x	
STROMATEIDAE								
Peprilus alepidotus								x
Peprilus burti	x	x	x	x		x	x	
SYNGNATHIDAE								x
Syngnathus louisianae						x		

Table 32. (Continued)

Taxon	EPA stations							
	Control				Field			
	A	D	E	H	B	C	F	G
SYNODONTIDAE								
Saurida sp.		x		x	x	x		
Synodus foetens						x		
Synodus sp.		x						
TETRAODONTIDAE								
Sphoeroides sp.	x	x				x	x	x
TRIGLIDAE								
Prionotus sp.	x	x	x	x	x		x	

Table 33. Comparison of egg abundance and distribution by family between EPA field and control stations by quarters from May 1976 to February 1977 taken from 0.333 mm bongo samples.

		Field stations					Control stations				
		No./1,000 m³				Family		No./1,000 m³			Family
Family	Date	B	C	F	G	totals	A	D	E	H	totals
Callionymidae	May 1976	48	0	0	0	5	0	159	0	0	25
Clupeidae		0	0	205	462	82	0	0	0	0	0
Engraulidae		676	35	0	308	105	29	0	0	2,479	289
Scombridae		0	0	307	0	41	0	0	235	0	10
Soleidae		0	0	0	0	0	0	64	353	0	25
Callionymidae	August 1976	0	80	83	68	29	0	36	38	0	11
Clupeidae		491	0	0	0	46	0	36	77	60	21
Engraulidae		0	0	83	68	21	0	0	77	3,313	304
Scombridae		0	478	220	990	433	0	0	0	2,530	224
Soleidae		45	0	0	102	17	0	0	0	1,145	101
Callionymidae	December 1976	0	0	0	0	0	0	0	0	0	0
Clupeidae		236	140	152	214	93	0	1,081	27	215	198
Engraulidae		0	0	0	0	0	0	0	0	0	0
Scombridae		0	0	0	0	0	0	0	0	0	0
Soleidae		0	35	0	0	4	0	0	0	0	0
Callionymidae	February 1977	0	0	0	0	0	0	0	0	0	0
Clupeidae		151	29	42	37	34	0	47	62	97	27
Engraulidae		75	0	0	18	13	0	0	0	19	3
Scombridae		0	0	0	0	0	0	0	0	0	0
Soleidae		0	0	0	0	0	0	0	0	0	0

Table 34. Identification and calculated numbers of EPA ichthyoplankton obtained from bongo samples by date, station and mesh size.

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
5/24	A	505	5,276	Bothidae	26
				Carangidae - *Chloroscombrus chrysurus*	26
				Ophichthidae	26
				Ophidiidae	26
				Tetraodontidae - *Sphoeroides* sp.	105
				Unknown	26
5/24	A	333	6,715	Carangidae - *Chloroscombrus chrysurus*	58
				Engraulidae - *Anchoa* sp.	29
				Gobiidae	58
				Tetraodontidae - *Sphoeroides* sp.	29
5/24	B	505	15,892	Clupeidae - *Harengula jaguana*	42
				Congridae	42
				Engraulidae - *Anchoa* sp.	125
				Gobiidae	42
				Pomadasyidae	42
				Serranidae - *Diplectrum* sp.	42
				Unknown	83
5/24	B	333	19,565	Cynoglossidae - *Symphurus* sp.	48
				Engraulidae	97
				Engraulidae - *Anchoa* sp.	48
				Gobiidae	97
				Microdesmidae - *Microdesmus* sp.	48
				Ophidiidae	48
				Triglidae - *Prionotus* sp.	48
				Unknown	48

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
5/24	C	505	20,494	Bothidae	216
				Bothidae - *Syacium gunteri*	154
				Carangidae	124
				Clupeidae - *Sardinella* sp.	31
				Engraulidae - *Anchoa* sp.	525
				Gobiidae	401
				Microdesmidae - *Microdesmus* sp.	93
				Ophidiidae	154
				Pomadasyidae	31
				Serranidae - *Diplectrum* sp.	93
				Serranidae - *Serraniculus pumilio*	31
				Tetraodontidae - *Sphoeroides* sp.	154
				Unknown	124
5/24	C	333	28,986	Bothidae	175
				Bothidae - *Syacium gunteri*	245
				Carangidae - *Decapterus punctatus*	35
				Cynoglossidae - *Symphurus* sp.	70
				Engraulidae	140
				Engraulidae - *Anchoa* sp.	245
				Gobiidae	664
				Labridae	35
				Microdesmidae - *Microdesmus* sp.	105
				Ophidiidae	70
				Scorpaenidae - *Scorpaena* sp.	35
				Serranidae - *Diplectrum* sp.	140
				Synodontidae - *Synodus foetens*	35
				Tetraodontidae - *Sphoeroides* sp.	105
				Unknown	70

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
5/24	D	505	6,578	Bothidae	59
				Bothidae - Syacium sp.	207
				Carangidae	30
				Carangidae - Chloroscombrus chrysurus	30
				Cynoglossidae - Symphurus sp.	30
				Engraulidae	148
				Engraulidae - Anchoa sp.	177
				Gobiidae	354
				Labridae	30
				Microdesmidae - Microdesmus sp.	59
				Ophidiidae	30
				Serranidae - Diplectrum sp.	266
				Serranidae - Serraniculus pumilio	89
				Synodontidae - Synodus sp.	30
				Tetraodontidae - Sphoeroides sp.	59
				Unknown	325
5/24	D	333	7,357	Blenniidae - Hypsoblennius sp.	32
				Bothidae	64
				Bothidae - Syacium sp.	64
				Bothidae - Syacium gunteri	64
				Carangidae - Decapterus punctatus	96
				Cynoglossidae - Symphurus sp.	96
				Engraulidae - Anchoa sp.	510
				Exocoetidae	32
				Gobiidae	637
				Ophidiidae	32
				Pomadasyidae	32
				Scorpaenidae - Scorpaena sp.	32
				Serranidae - Diplectrum sp.	350

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
5/24	D	333		Tetraodontidae - *Sphoeroides* sp.	64
				Unknown	319
5/25	E	505	5,824	Bothidae - *Syacium* sp.	110
				Engraulidae - *Anchoa* sp.	110
				Ophidiidae	110
5/25	E	333	6,941	Engraulidae	118
5/25	F	505	6,323	Bothidae - *Syacium* sp.	32
				Carangidae	32
				Carangidae - *Chloroscombrus chrysurus*	32
				Cynoglossidae - *Symphurus* sp.	129
				Engraulidae	32
				Engraulidae - *Anchoa* sp.	65
				Gobiidae	32
				Tetraodontidae - *Sphoeroides* sp.	32
				Unknown	32
5/25	F	333	7,167	Bothidae	102
				Bothidae - *Syacium* sp.	68
				Cynoglossidae - *Symphurus* sp.	68
				Engraulidae	205
				Gobiidae	68
				Microdesmidae - *Microdesmus* sp.	34
				Unknown	34
5/25	G	505	8,188	Carangidae - *Chloroscombrus chrysurus*	109
				Cynoglossidae - *Symphurus* sp.	36
				Engraulidae - *Anchoa* sp.	254

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
5/25	G	505		Gobiidae	36
				Syngnathidae - *Syngnathus louisianae*	36
				Tetraodontidae - *Sphoeroides* sp.	73
5/25	G	333	8,885	Bothidae	115
				Carangidae - *Decapterus punctatus*	77
				Cynoglossidae - *Symphurus* sp.	77
				Engraulidae	77
				Gobiidae	77
				Stromateidae - *Peprilus alepidotus*	39
				Tetraodontidae - *Sphoeroides* sp.	39
				Unknown	77
5/25	H	505	6,087	Carangidae	40
				Cynoglossidae - *Symphurus* sp.	40
				Engraulidae	79
5/25	H	333	13,932	Carangidae - *Decapterus punctatus*	43
				Cynoglossidae - *Symphurus* sp.	43
				Engraulidae	43
				Unknown	43
8/16	A	505	213	Carangidae	53
				Clupeidae	160
				Engraulidae	106
				Engraulidae - *Anchoa* sp.	106
				Scombridae	53
				Scombridae - *Scomberomorus maculatus*	106
				Unknown	53

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
8/16	A	333	1,802	Carangidae	349
				Clupeidae	1,337
				Cynoglossidae - *Symphurus* sp.	116
				Engraulidae	58
				Gerreidae	58
				Gobiidae	174
				Scombridae	349
				Scombridae - *Scomberomorus cavalla*	58
				Unknown	988
8/16	B	505	4,032	Bothidae - *Syacium gunteri*	161
				Carangidae	121
				Clupeidae	40
				Engraulidae	444
				Engraulidae - *Engraulis eurystole*	847
				Gobiidae	161
				Scombridae	363
				Scombridae - *Euthynnus alletteratus*	40
				Scombridae - *Scomberomorus cavalla*	81
				Synodontidae - *Saurida* sp.	40
8/16	B	333	5,446	Bothidae - *Syacium gunteri*	45
				Carangidae	45
				Clupeidae	357
				Engraulidae	982
				Engraulidae - *Anchoa* sp.	134
				Gobiidae	268
				Muraenidae - *Gymnothorax* sp.	45
				Ophidiidae	89
				Sciaenidae - *Bairdiella chrysura*	45

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
8/16	B	333		Scombridae	268
				Scombridae - *Euthynnus alletteratus*	134
				Unknown	223
8/17	C	505	1,477	Bothidae - *Syacium* sp.	76
				Carangidae	265
				Carangidae - *Decapterus punctatus*	38
				Engraulidae	341
				Engraulidae - *Engraulis eurystole*	152
				Scombridae - *Euthynnus alletteratus*	76
				Serranidae - *Diplectrum* sp.	38
				Sphyraenidae - *Sphyraena* sp.	38
				Unknown	38
8/17	C	333	2,151	Bothidae	40
				Bothidae - *Syacium* sp.	80
				Carangidae	199
				Carangidae - *Decapterus punctatus*	40
				Clupeidae	239
				Engraulidae	757
				Engraulidae - *Engraulis eurystole*	239
				Gobiidae	438
				Scombridae - *Scomberomorus maculatus*	40
				Serranidae - *Diplectrum* sp.	80
				Unknown	438
8/17	D	505	129	Bothidae - *Syacium* sp.	64
				Bothidae - *Syacium gunteri*	32
				Carangidae	64
				Carangidae - *Decapterus punctatus*	64

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
8/17	D	505		Clupeidae	64
				Cynoglossidae - *Symphurus* sp.	161
				Engraulidae	5,756
				Engraulidae - *Engraulis eurystole*	579
				Gobiidae	32
				Sciaenidae	32
				Scombridae - *Scomberomorus maculatus*	32
				Unknown	32
8/17	D	333	214	Bothidae - *Syacium* sp.	142
				Carangidae	320
				Cynoglossidae - *Symphurus* sp.	285
				Engraulidae	9,537
				Engraulidae - *Engraulis eurystole*	1,281
				Gobiidae	214
				Unknown	285
8/17	E	505	4,489	Bothidae	37
				Carangidae	365
				Carangidae - *Decapterus punctatus*	37
				Engraulidae	110
				Ogcocephalidae	37
				Scombridae	37
				Triglidae - *Prionotus* sp.	37
				Unknown	73
8/17	E	333	4,674	Bothidae - *Syacium gunteri*	38
				Carangidae	307
				Clupeidae	115
				Cynoglossidae - *Symphurus* sp.	77

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
8/17	E	333		Engraulidae	192
				Unknown	77
8/17	F	505	1,148	Carangidae	332
				Carangidae - *Decapterus punctatus*	51
				Clupeidae	128
				Clupeidae - *Opisthonema oglinum*	77
				Cynoglossidae - *Symphurus* sp.	26
				Engraulidae	638
				Gobiidae	128
				Sciaenidae	26
				Scombridae - *Euthynnus alletteratus*	77
				Unknown	383
8/17	F	333	4,187	Bothidae - *Syacium* sp.	193
				Bothidae - *Syacium gunteri*	28
				Carangidae	468
				Clupeidae	83
				Cynoglossidae - *Symphurus* sp.	138
				Engraulidae	2,507
				Gobiidae	193
				Microdesmidae - *Microdesmus* sp.	55
				Scombridae	55
				Scombridae - *Euthynnus alletteratus*	28
				Scombridae - *Scomberomorus maculatus*	83
				Sphyraenidae - *Sphyraena* sp.	28
				Tetraodontidae - *Sphoeroides* sp.	28
				Unknown	1,267
8/17	G	505	2,837	Carangidae	201

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
8/17	G	505		Carangidae - *Decapterus punctatus*	29
				Engraulidae	1,032
				Gobiidae	57
				Scombridae	29
				Scombridae - *Euthynnus alletteratus*	57
				Unknown	86
8/17	G	333	4,881	Bothidae - *Syacium* sp.	34
				Carangidae	478
				Engraulidae	1,399
				Gobiidae	68
				Scombridae - *Euthynnus alletteratus*	34
				Unknown	68
8/17	H	505	4,054	Carangidae	90
				Cynoglossidae - *Symphurus* sp.	135
				Engraulidae	135
				Gobiidae	45
				Scombridae	90
				Scombridae - *Scomberomorus cavalla*	45
				Serranidae - *Serraniculus pumilio*	45
8/17	H	333	18,193	Carangidae	60
				Clupeidae	60
				Cynoglossidae - *Symphurus* sp.	60
				Engraulidae	181
				Gobiidae	60
				Scombridae	121
				Scombridae - *Scomberomorus maculatus*	60
				Unknown	301

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
12/4	A	505	161	Engraulidae	40
12/4	A	333	41	---	0
12/4	B	505	4,619	Clupeidae - *Brevoortia* sp.	85
				Engraulidae - *Anchoa* sp.	42
				Engraulidae - *Engraulis eurystole*	42
				Sciaenidae - *Leiostomus xanthurus*	42
12/4	B	333	276	Bothidae	39
				Bothidae - *Paralichthys* sp.	197
				Gobiidae	39
				Sciaenidae	79
				Sciaenidae - *Micropogon undulatus*	79
				Unknown	39
12/4	C	505	270	Bothidae	39
				Bothidae - *Paralichthys* sp.	39
				Clupeidae	39
				Engraulidae	39
				Engraulidae - *Engraulis eurystole*	39
				Sciaenidae	77
12/4	C	333	211	Bothidae	70
				Bothidae - *Paralichthys* sp.	281
				Gobiidae	281
				Sciaenidae	105
				Sciaenidae - *Leiostomus xanthurus*	35
				Unknown	35

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
12/4	D	505	2,687	Clupeidae	26
				Gobiidae	26
				Unknown	26
12/4	D	333	1,695	Clupeidae	25
				Gobiidae	49
				Sciaenidae - *Leiostomus xanthurus*	25
				Sparidae	25
				Stromateidae - *Peprilus burti*	25
				Synodontidae - *Saurida* sp.	25
				Unknown	246
12/3	E	505	58	Bothidae - *Paralichthys* sp.	87
				Gobiidae	116
				Sciaenidae - *Leiostomus xanthurus*	29
				Sciaenidae - *Micropogon undulatus*	29
12/3	E	333	55	Bothidae	28
				Bothidae - *Paralichthys* sp.	192
				Gobiidae	412
				Sciaenidae	137
				Sciaenidae - *Leiostomus xanthurus*	110
				Stromateidae - *Peprilus burti*	28
12/3	F	505	276	Bothidae	25
				Bothidae - *Paralichthys* sp.	25
				Engraulidae - *Anchoa* sp.	25
				Gobiidae	226
				Sciaenidae	476
				Sciaenidae - *Leiostomus xanthurus*	125

Table 34. (Continued)

Date (1976)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
12/3	F	505		Triglidae - *Prionotus* sp.	25
				Unknown	50
12/3	F	333	254	Bothidae	102
				Bothidae - *Paralichthys* sp.	432
				Engraulidae - *Engraulis eurystole*	25
				Gobiidae	381
				Sciaenidae	432
				Sciaenidae - *Leiostomus xanthurus*	76
				Sciaenidae - *Micropogon undulatus*	51
				Unknown	102
12/3	G	505	531	Bregmacerotidae - *Bregmaceros atlanticus*	31
				Engraulidae	31
				Gobiidae	156
				Sciaenidae	94
				Sciaenidae - *Leiostomus xanthurus*	94
				Sciaenidae - *Micropogon undulatus*	63
12/3	G	333	214	Bothidae	153
				Bothidae - *Paralichthys* sp.	367
				Clupeidae	61
				Engraulidae - *Anchoa* sp.	31
				Gobiidae	489
				Sciaenidae	153
				Sciaenidae - *Leiostomus xanthurus*	31
				Sciaenidae - *Micropogon undulatus*	92
				Unknown	214
12/3	H	505	462	Bothidae	33

Table 34. (Continued)

Date (76-77)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
12/3	H	505		Gobiidae	33
				Sciaenidae - *Leiostomus xanthurus*	99
				Sciaenidae - *Micropogon undulatus*	33
				Unknown	66
12/3	H	333	492	Bothidae	123
				Bothidae - *Paralichthys* sp.	62
				Bregmacerotidae - *Bregmaceros atlanticus*	31
				Clupeidae	62
				Gobiidae	154
				Sciaenidae	92
				Sciaenidae - *Leiostomus xanthurus*	62
				Sciaenidae - *Micropogon undulatus*	62
				Synodontidae - *Saurida* sp.	62
				Unknown	246
2/19	A	505	46	Clupeidae - *Brevoortia* sp.	46
				Sparidae - *Lagodon rhomboides*	23
				Stromateidae - *Peprilus burti*	23
				Unknown	23
2/19	A	333	23	Stromateidae - *Peprilus burti*	23
2/19	B	505	153	Clupeidae	19
				Clupeidae - *Brevoortia* sp.	38
2/19	B	333	245	Clupeidae	76
				Clupeidae - *Brevoortia* sp.	19
				Myctophidae - *Lampanyctus* sp.	19
				Unknown	94

Table 34. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/19	C	505	115	Sciaenidae - *Micropogon undulatus*	29
2/19	C	333	58	Bothidae - *Paralichthys* sp.	29
				Bregmacerotidae - *Bregmaceros atlanticus*	29
				Clupeidae	29
				Clupeidae - *Brevoortia* sp.	58
				Myctophidae - *Notoscopelus resplendens*	29
				Serranidae	58
				Stromateidae - *Peprilus burti*	58
2/19	D	505	224	Bothidae	25
				Clupeidae	25
				Clupeidae - *Brevoortia* sp.	75
				Gobiidae	25
				Sciaenidae - *Micropogon undulatus*	25
				Serranidae	25
				Stromateidae - *Peprilus burti*	25
2/19	D	333	187	Bregmacerotidae - *Bregmaceros atlanticus*	23
				Clupeidae	23
				Clupeidae - *Brevoortia* sp.	47
				Unknown	47
2/19	E	505	155	Clupeidae	62
				Clupeidae - *Brevoortia* sp.	93
2/19	E	333	92	Bothidae - *Paralichthys* sp.	31
				Carangidae - *Trachurus lathami*	31
				Clupeidae	31
				Unknown	31

Table 34. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/19	F	505	128	Bothidae	21
				Bothidae - *Paralichthys* sp.	21
				Clupeidae - *Brevoortia* sp.	21
				Sciaenidae - *Micropogon undulatus*	21
				Triglidae - *Prionotus* sp.	21
				Unknown	21
2/19	F	333	149	Bothidae - *Paralichthys* sp.	21
				Myctophidae - *Diaphus* sp.	21
				Serranidae	21
				Stromateidae - *Peprilus burti*	21
				Unknown	85
2/19	G	505	200	Sparidae	18
				Sparidae - *Lagodon rhomboides*	18
2/19	G	333	74	Gobiidae	37
				Unknown	37
2/19	H	505	205	Clupeidae	41
				Clupeidae - *Brevoortia* sp.	349
				Sparidae	21
				Sparidae - *Lagodon rhomboides*	41
				Stromateidae - *Peprilus burti*	21
				Unknown	21
2/19	H	333	193	Bothidae	19
				Bothidae - *Paralichthys* sp.	19
				Clupeidae - *Brevoortia* sp.	58
				Sciaenidae - *Micropogon undulatus*	19

Table 34. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/19	H	333		Sparidae - *Lagodon rhomboides*	19
				Stromateidae - *Peprilus burti*	19
				Triglidae - *Prionotus* sp.	19

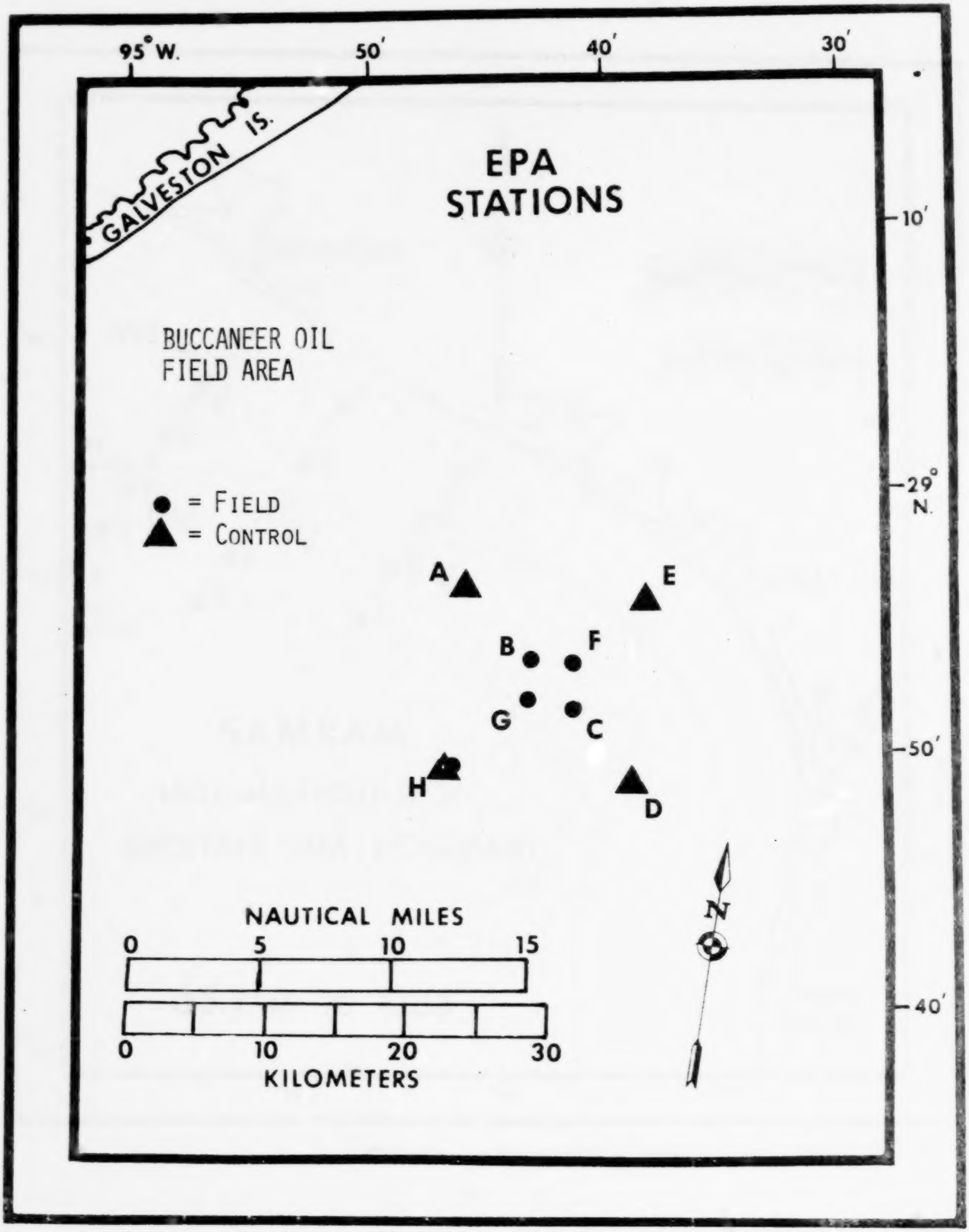

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
10′
BUCCANEER OIL FIELD AREA
● = FIELD
▲ = CONTROL
29° N.
A
E
B
F
G
C
H
D
50′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
N
40′

Figure 1 Location of Buccaneer oil field area ichthyoplankton stations.

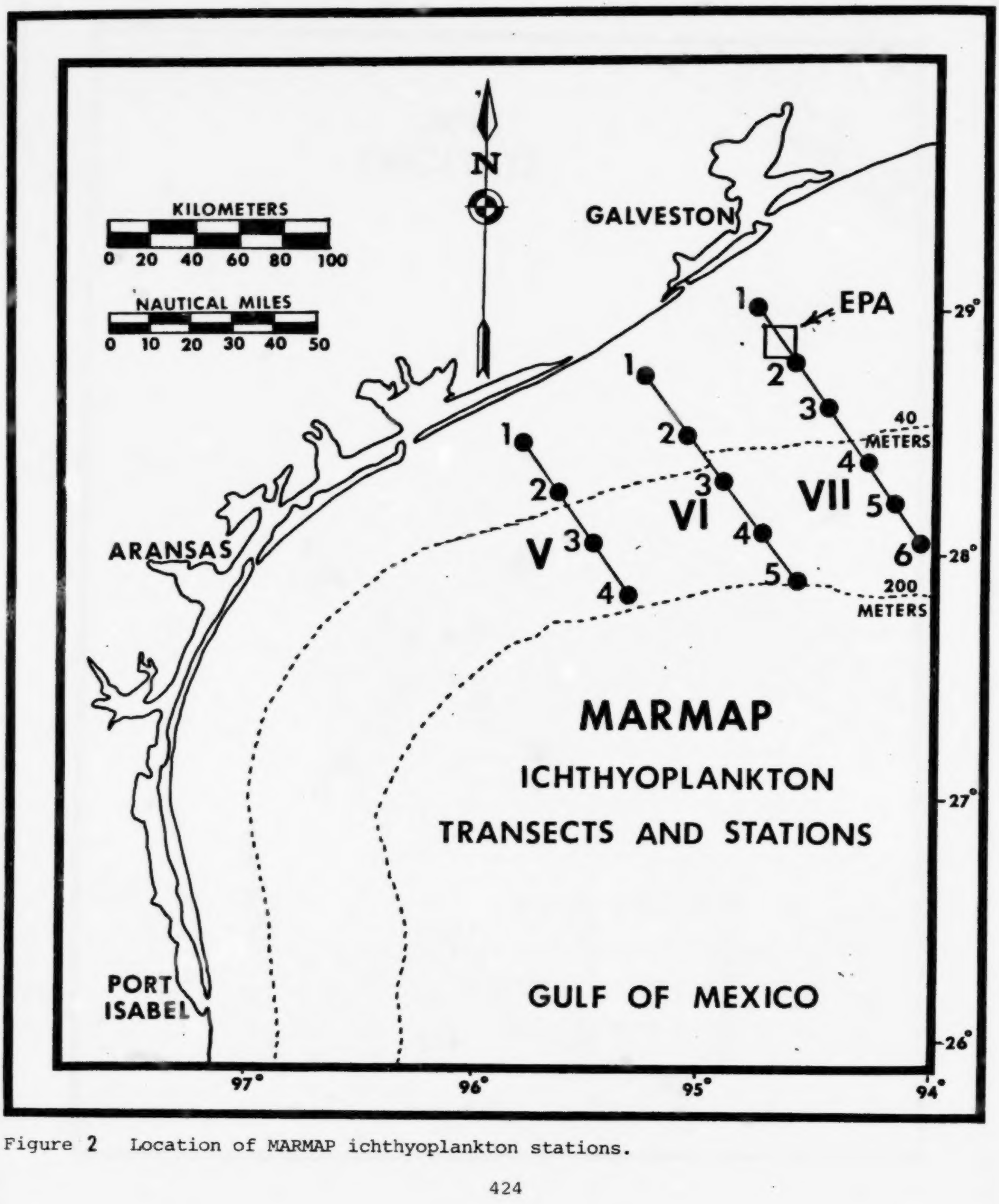

MARMAP
ICHTHYOPLANKTON
TRANSECTS AND STATIONS
GULF OF MEXICO
GALVESTON
ARANSAS
PORT ISABEL
EPA
KILOMETERS
0 20 40 60 80 100
NAUTICAL MILES
0 10 20 30 40 50
N
V
VI
VII
1
2
3
4
5
6
40 METERS
200 METERS
29°
28°
27°
26°
97°
96°
95°
94°

Figure 2 Location of MARMAP ichthyoplankton stations.

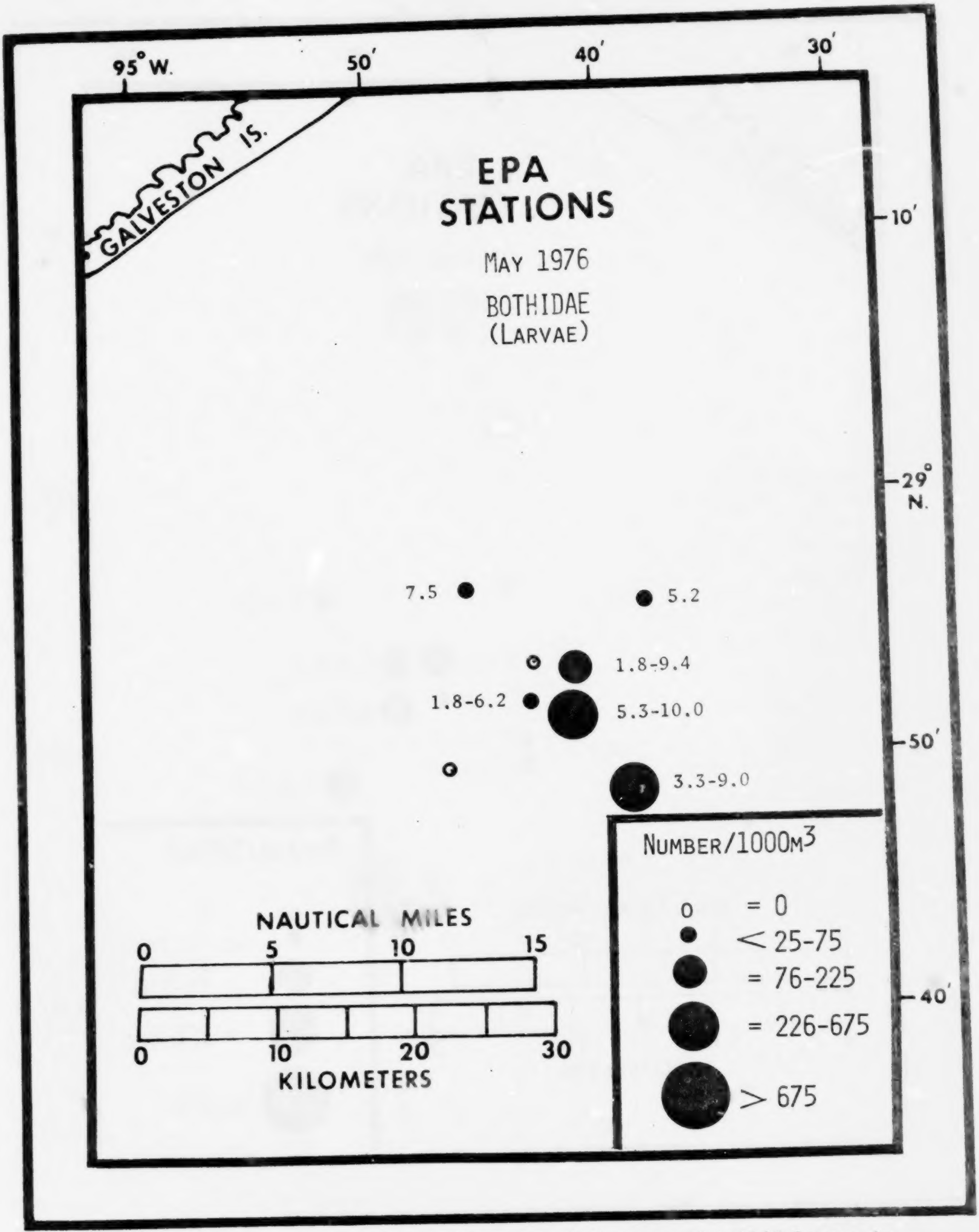

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
MAY 1976
BOTHIDAE
(LARVAE)
10′
29° N.
50′
40′
7.5
5.2
1.8-9.4
1.8-6.2
5.3-10.0
3.3-9.0
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
• < 25-75
= 76-225
= 226-675
> 675

Figure 3. Distribution, abundance and size range (SL) in mm of bothid larvae in the Buccaneer oil field area during May 1976.

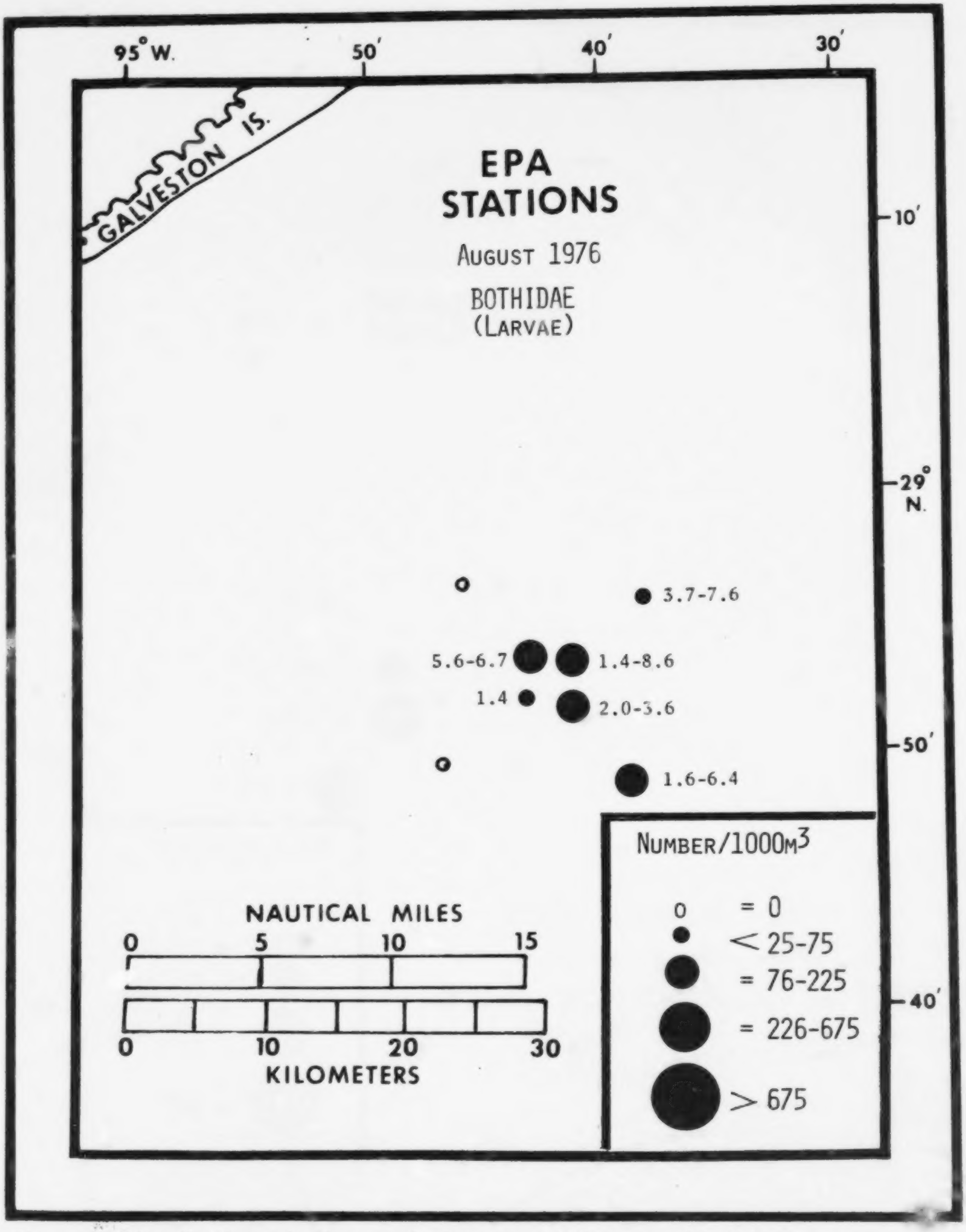

95° W.
50'
40'
30'
GALVESTON IS.
EPA STATIONS
August 1976
BOTHIDAE
(Larvae)
10'
29° N.
50'
40'
3.7-7.6
5.6-6.7
1.4-8.6
1.4
2.0-3.6
1.6-6.4
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
Number/1000m³
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 4. Distribution, abundance and size range (SL) in mm of bothid larvae in the Buccaneer oil field area during August 1976.

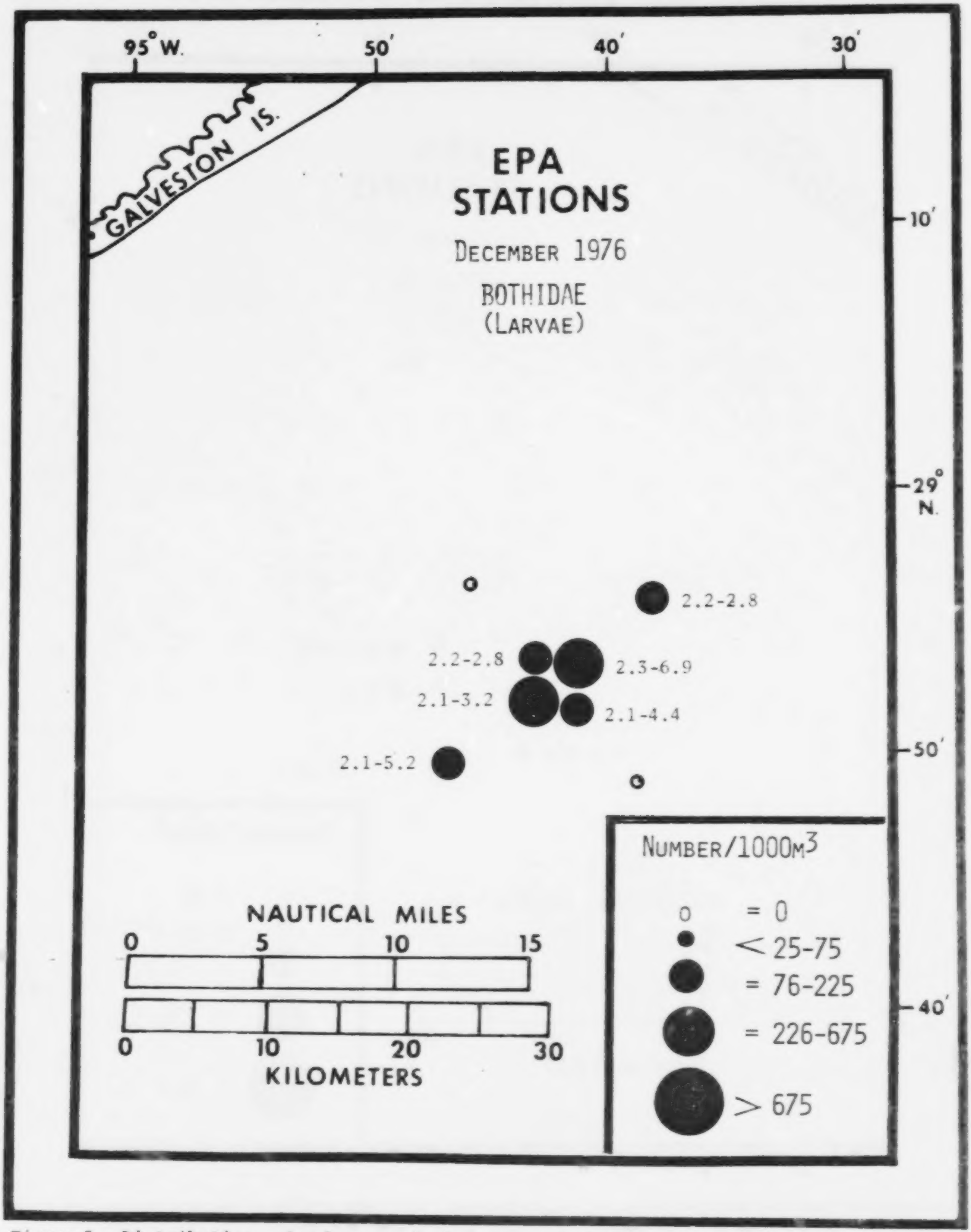

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
BOTHIDAE
(LARVAE)
2.2-2.8
2.2-2.8
2.3-6.9
2.1-3.2
2.1-4.4
2.1-5.2
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M^3
= 0
< 25-75
= 76-225
= 226-675
> 675

Figure 5. Distribution, abundance and size range (SL) in mm of bothid larvae in the Buccaneer oil field area during December 1976.

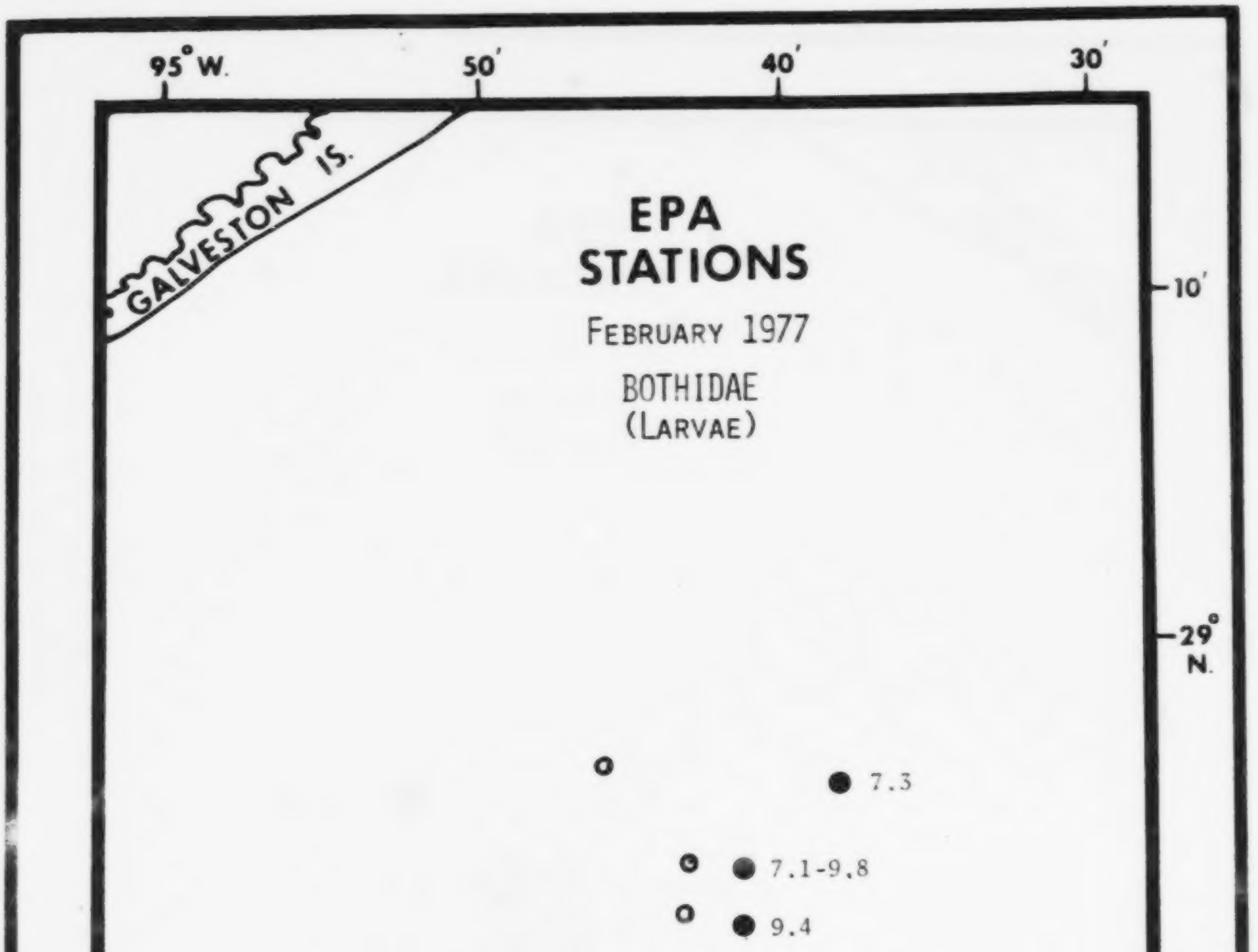

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
BOTHIDAE (LARVAE)
10′
29° N.
50′
40′
7.3
7.1-9.8
9.4
7.8-10.4
13.7
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 6. Distribution, abundance and size range (SL) in mm of bothid larvae in the Buccaneer oil field area during February 1977.

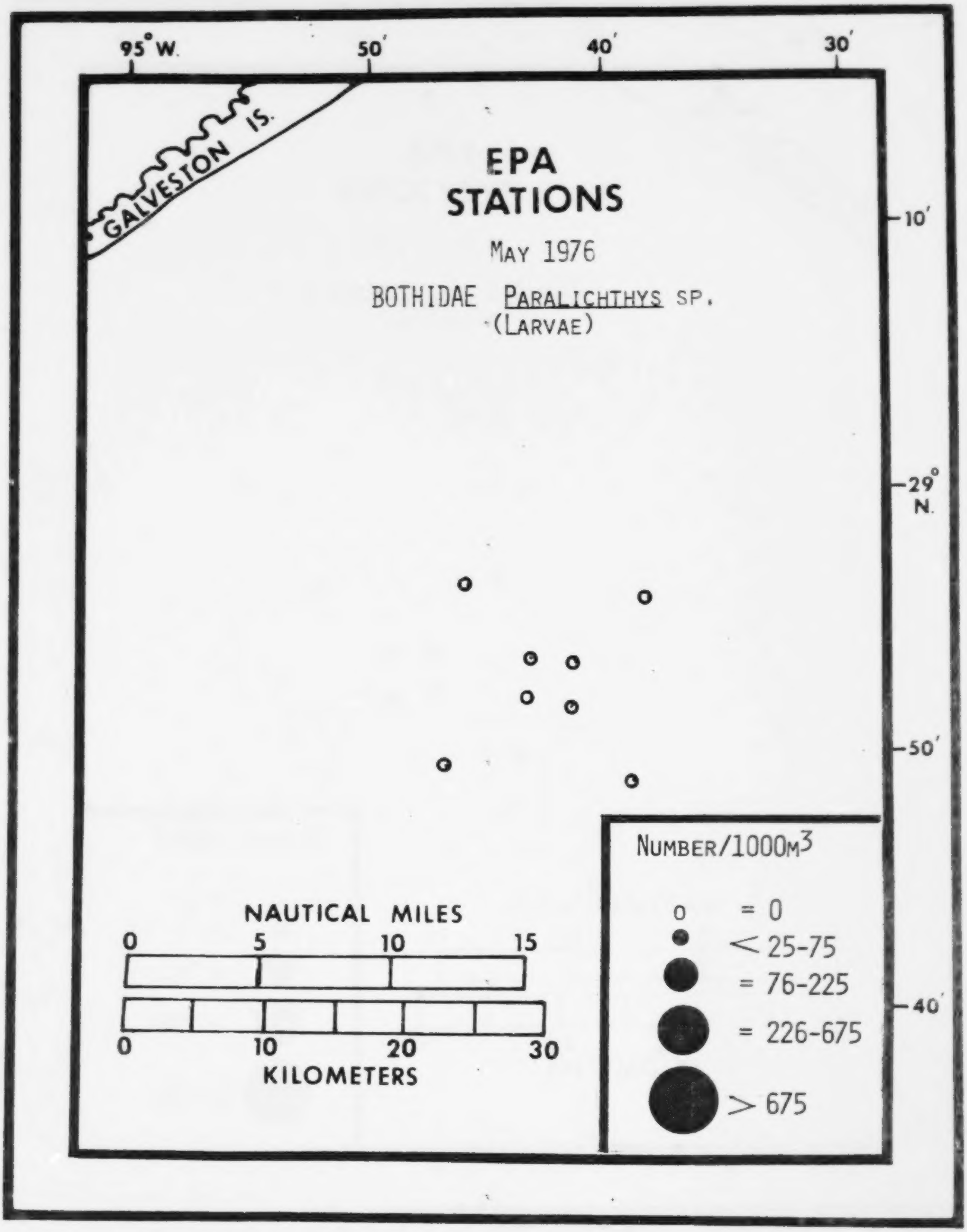

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
MAY 1976
BOTHIDAE PARALICHTHYS SP.
(LARVAE)
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
• < 25-75
= 76-225
= 226-675
> 675

Figure 7. Distribution, abundance and size range (SL) in mm of Paralichthys sp. larvae in the Buccaneer oil field area during May 1976.

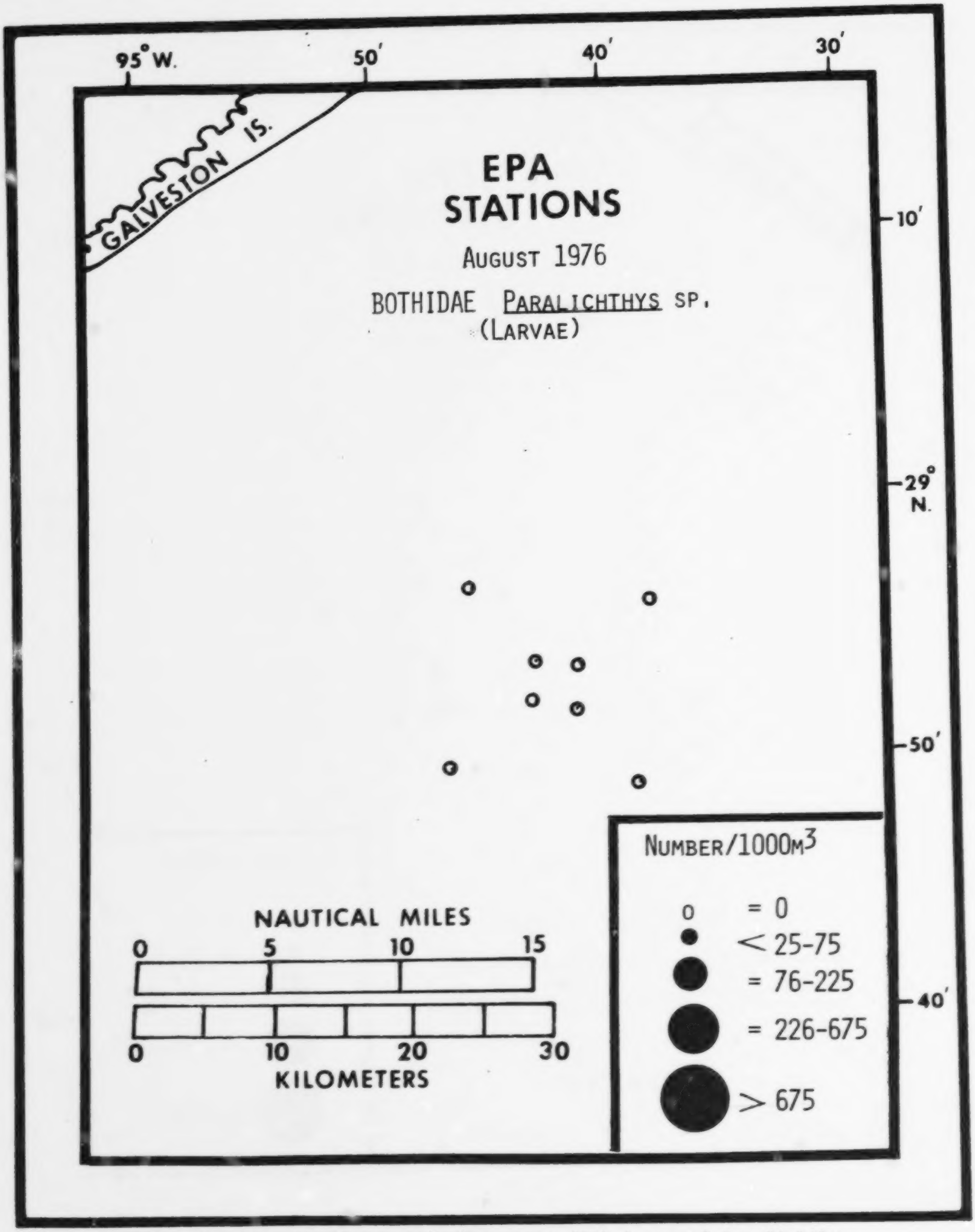

95° W.
50'
40'
30'
GALVESTON IS.
EPA
STATIONS
AUGUST 1976
BOTHIDAE Paralichthys sp.
(LARVAE)
10'
29° N.
50'
40'
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
• < 25-75
● = 76-225
● = 226-675
● > 675

Figure 8. Distribution, abundance and size range (SL) in mm of *Paralichthys* sp. larvae in the Buccaneer oil field area during August 1976.

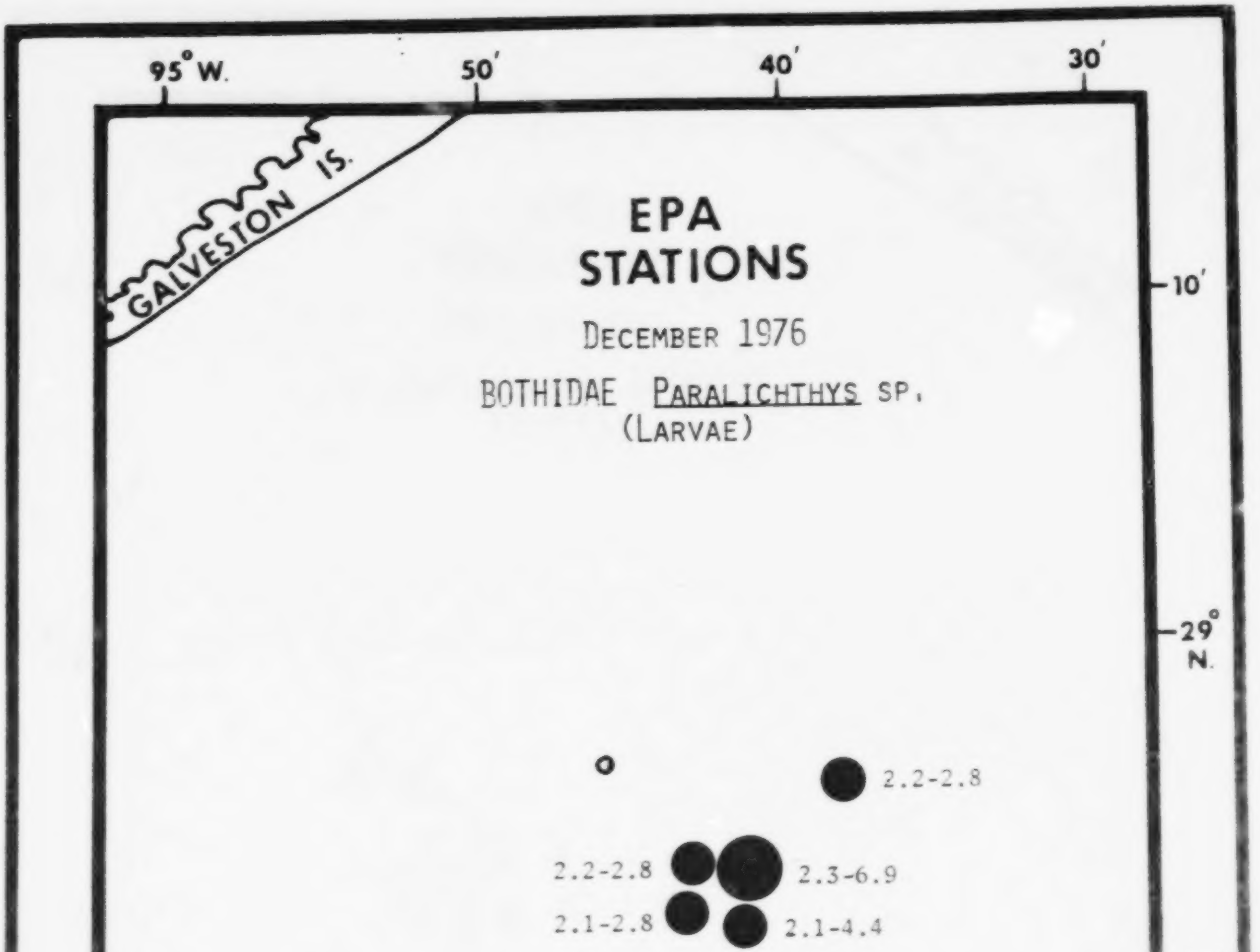

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
BOTHIDAE PARALICHTHYS SP.
(LARVAE)
10′
29° N.
50′
40′
2.2-2.8
2.2-2.8
2.3-6.9
2.1-2.8
2.1-4.4
2.1-2.2
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 9. Distribution, abundance and size range (SL) in mm of Paralicnthys sp. larvae in the Buccaneer oil field area during December 1976.

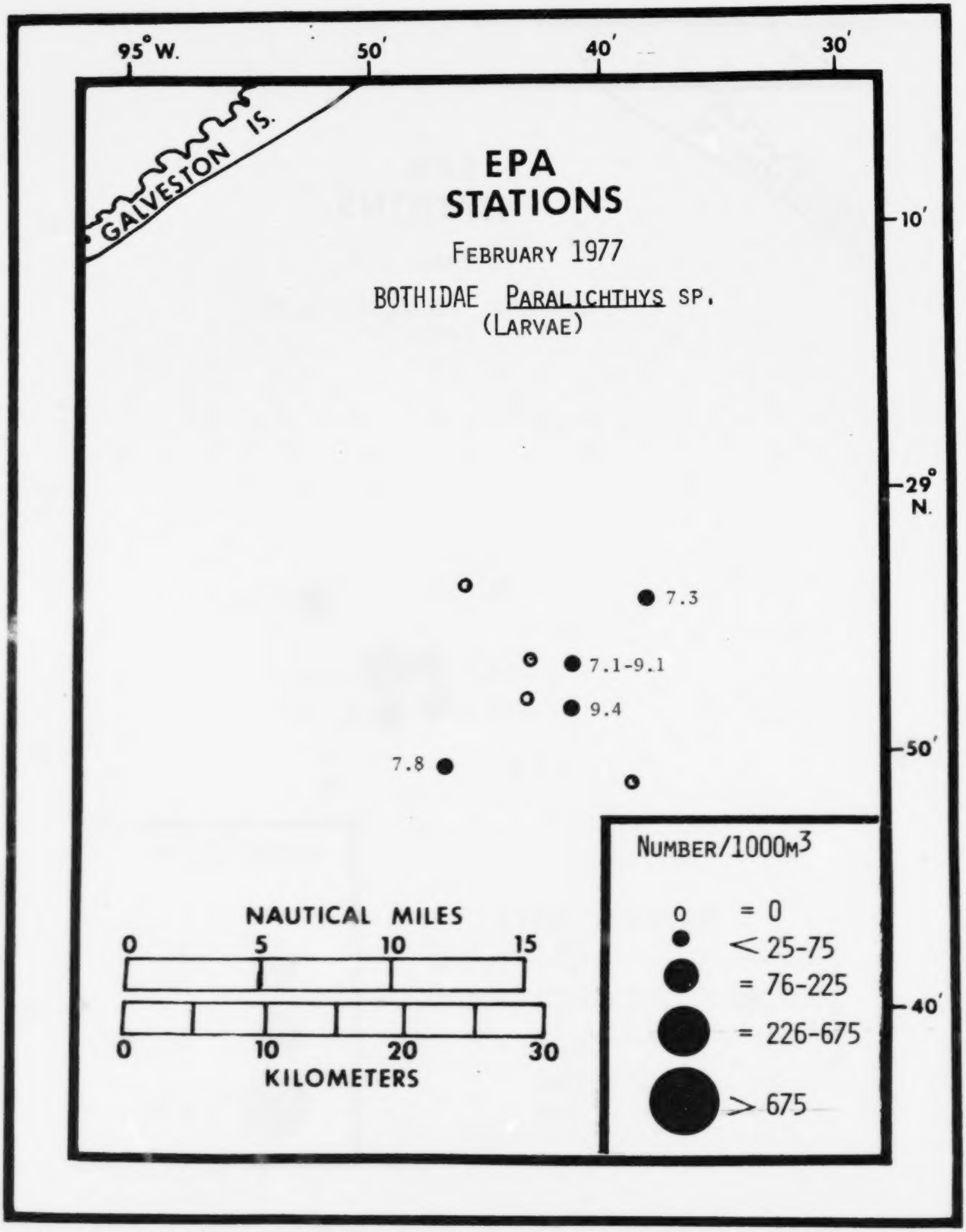

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
BOTHIDAE PARALICHTHYS SP.
(LARVAE)
7.3
7.1-9.1
9.4
7.8
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 10. Distribution, abundance and size range (SL) in mm of *Paralichthys* sp. larvae in the Buccaneer oil field area during February 1977.

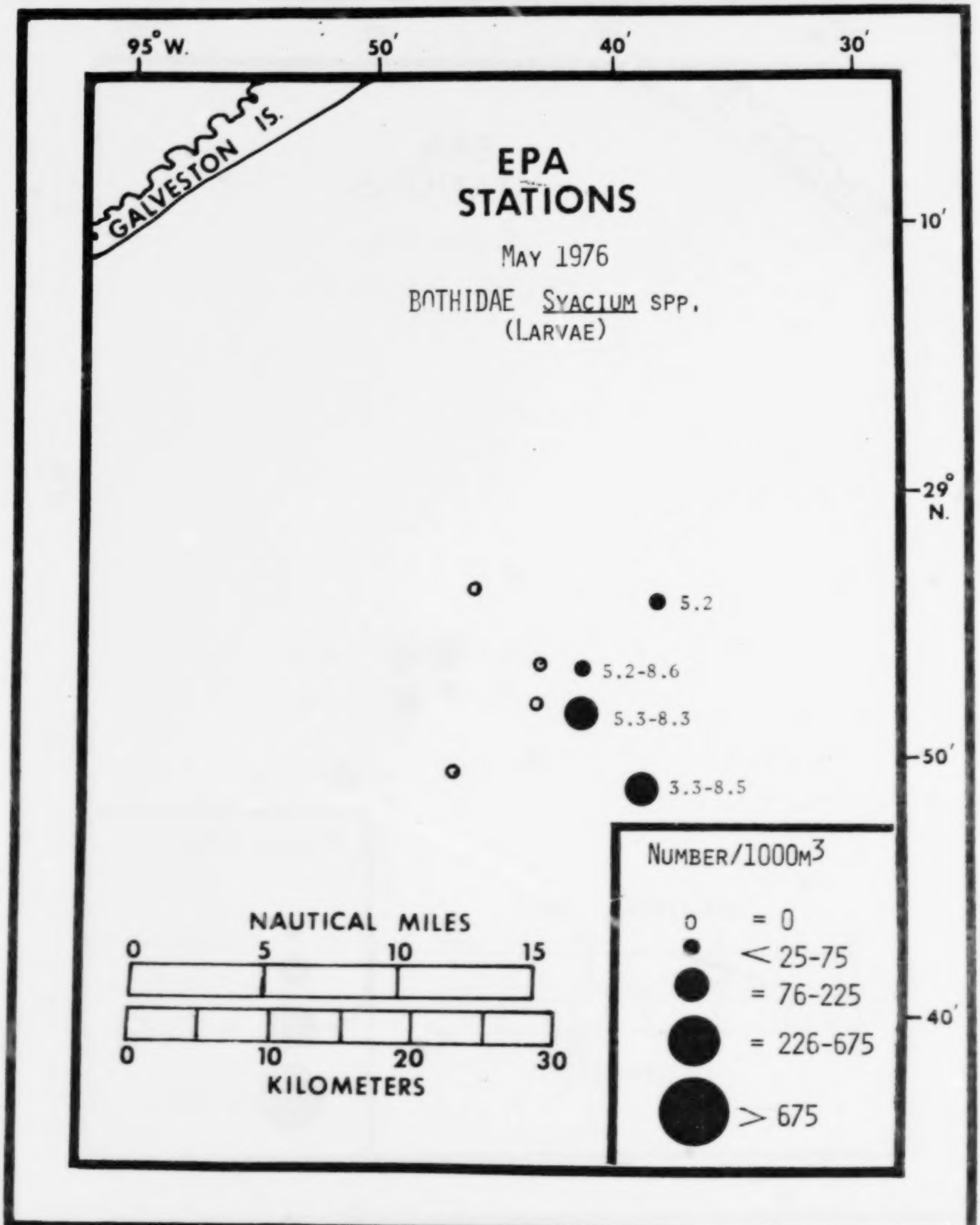

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
MAY 1976
BOTHIDAE Syacium SPP.
(LARVAE)
10′
29° N.
50′
40′
5.2
5.2-8.6
5.3-8.3
3.3-8.5
NUMBER/1000M^3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 11. Distribution, abundance and size range (SL) in mm of *Syacium* spp. larvae in the Buccaneer oil field area during May 1976.

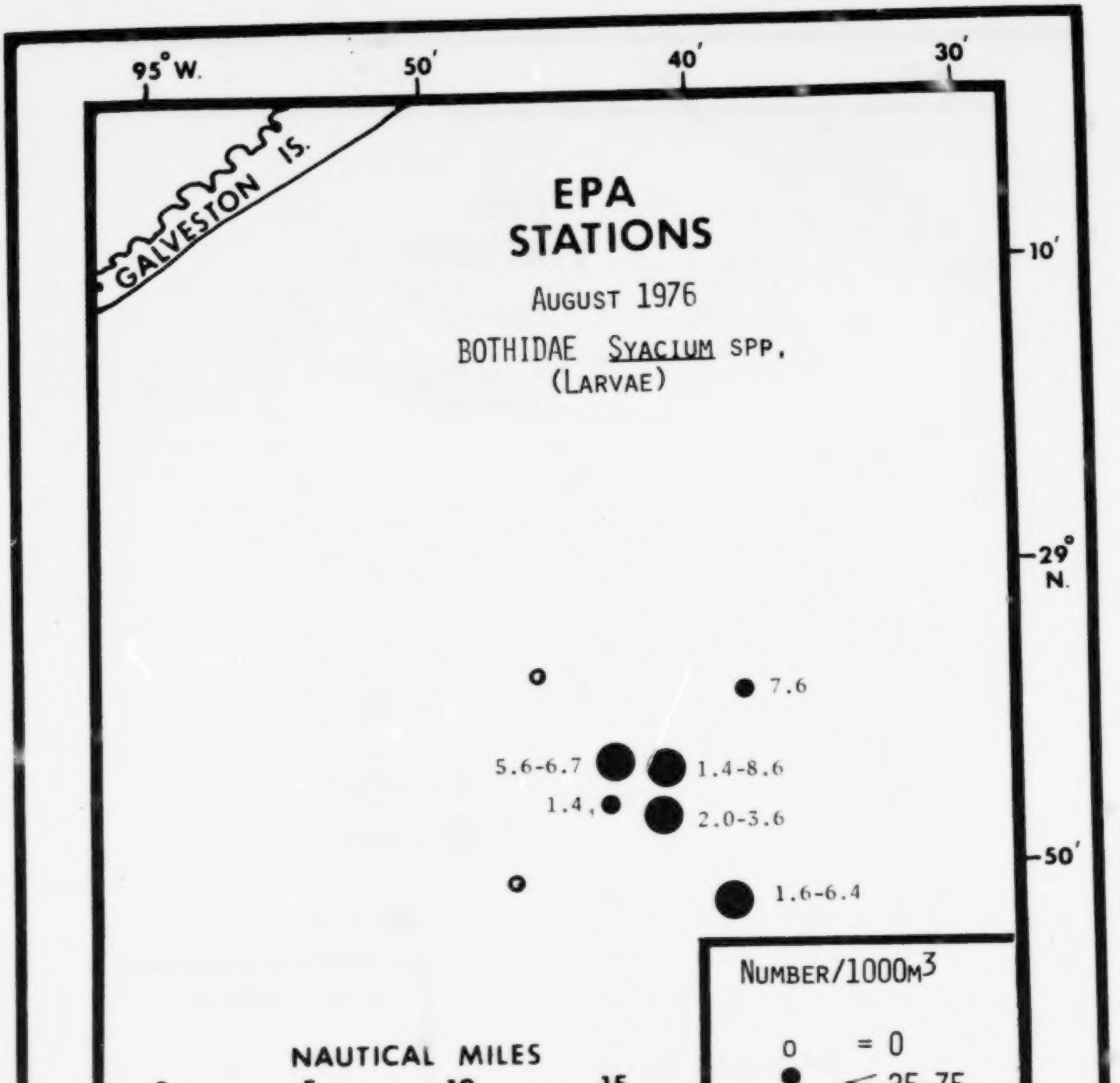

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
AUGUST 1976
BOTHIDAE Syacium SPP.
(LARVAE)
7.6
5.6-6.7
1.4-8.6
1.4,
2.0-3.6
1.6-6.4
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 12. Distribution, abundance and size range (SL) in mm of Syacium spp. larvae in the Buccaneer oil field area during August 1976.

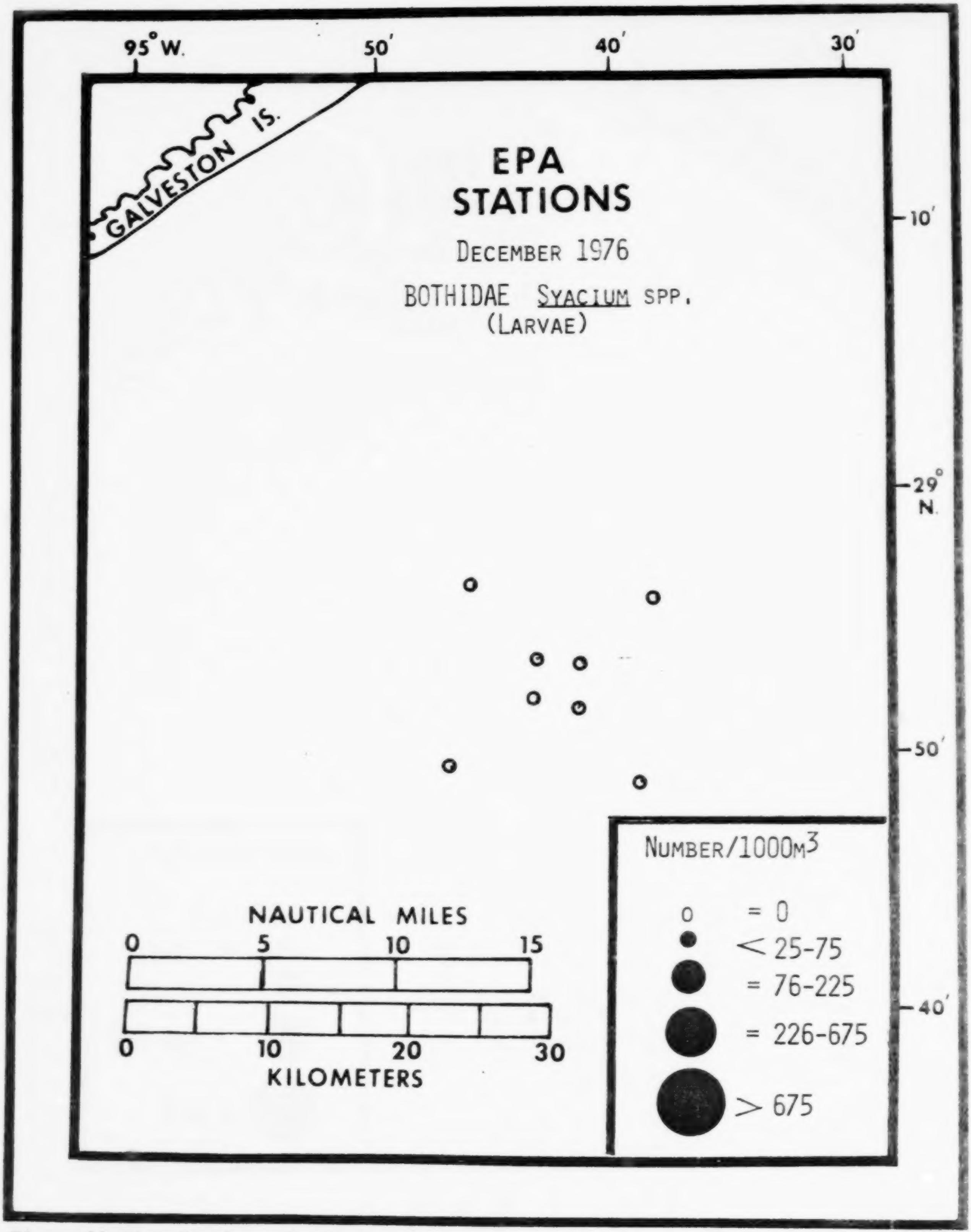

95° W.
50'
40'
30'
10'
29° N.
50'
40'
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
BOTHIDAE SYACIUM SPP.
(LARVAE)
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 13. Distribution, abundance and size range (SL) in mm of Syacium spp. larvae in the Buccaneer oil field area during December 1976.

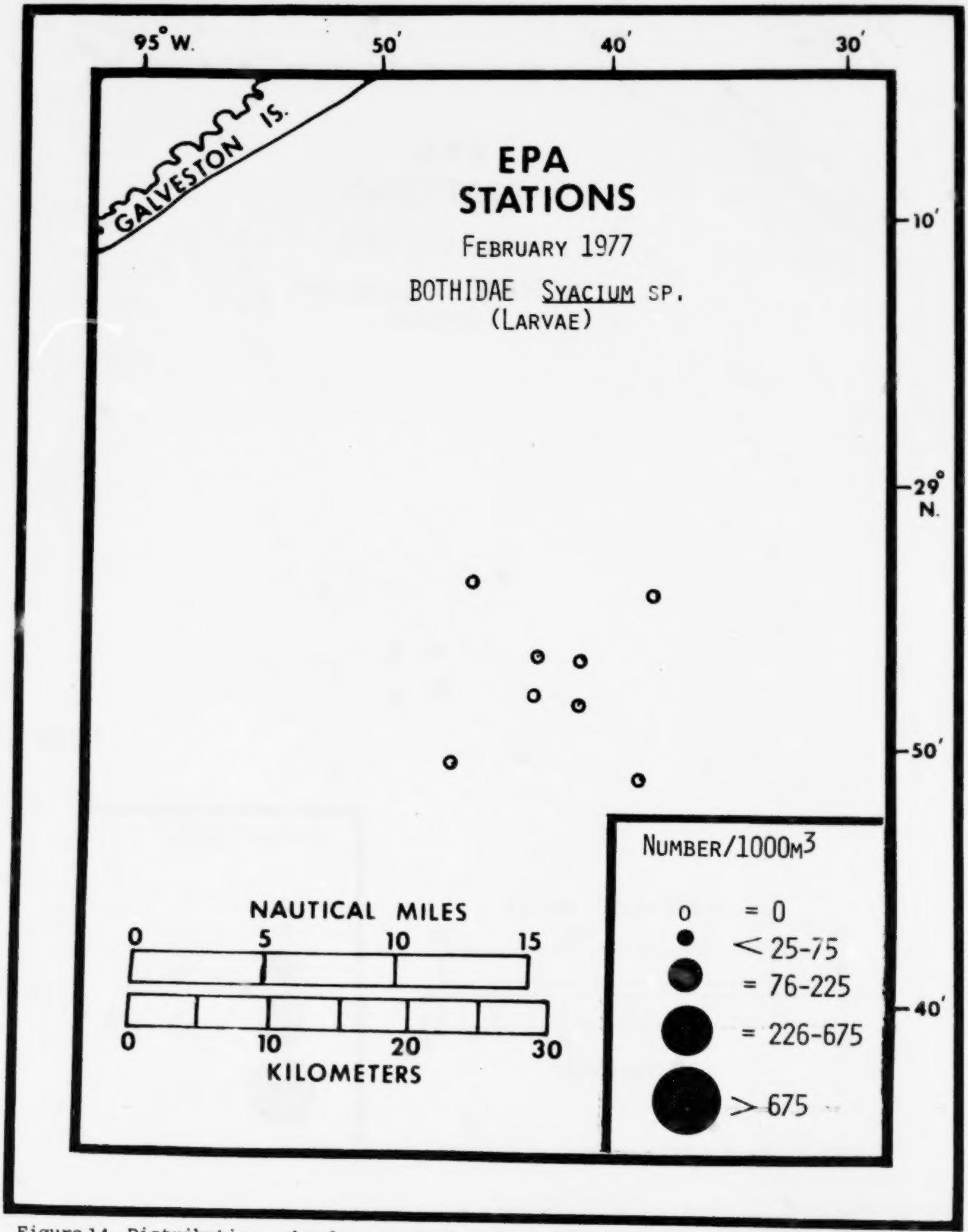

95° W.
50'
40'
30'
GALVESTON IS.
EPA
STATIONS
FEBRUARY 1977
BOTHIDAE Syacium SP.
(LARVAE)
10'
29° N.
50'
40'
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
• < 25-75
= 76-225
= 226-675
> 675

Figure 14. Distribution, abundance and size range (SL) in mm of Syacium spp. larvae in the Buccaneer oil field area during February 1977.

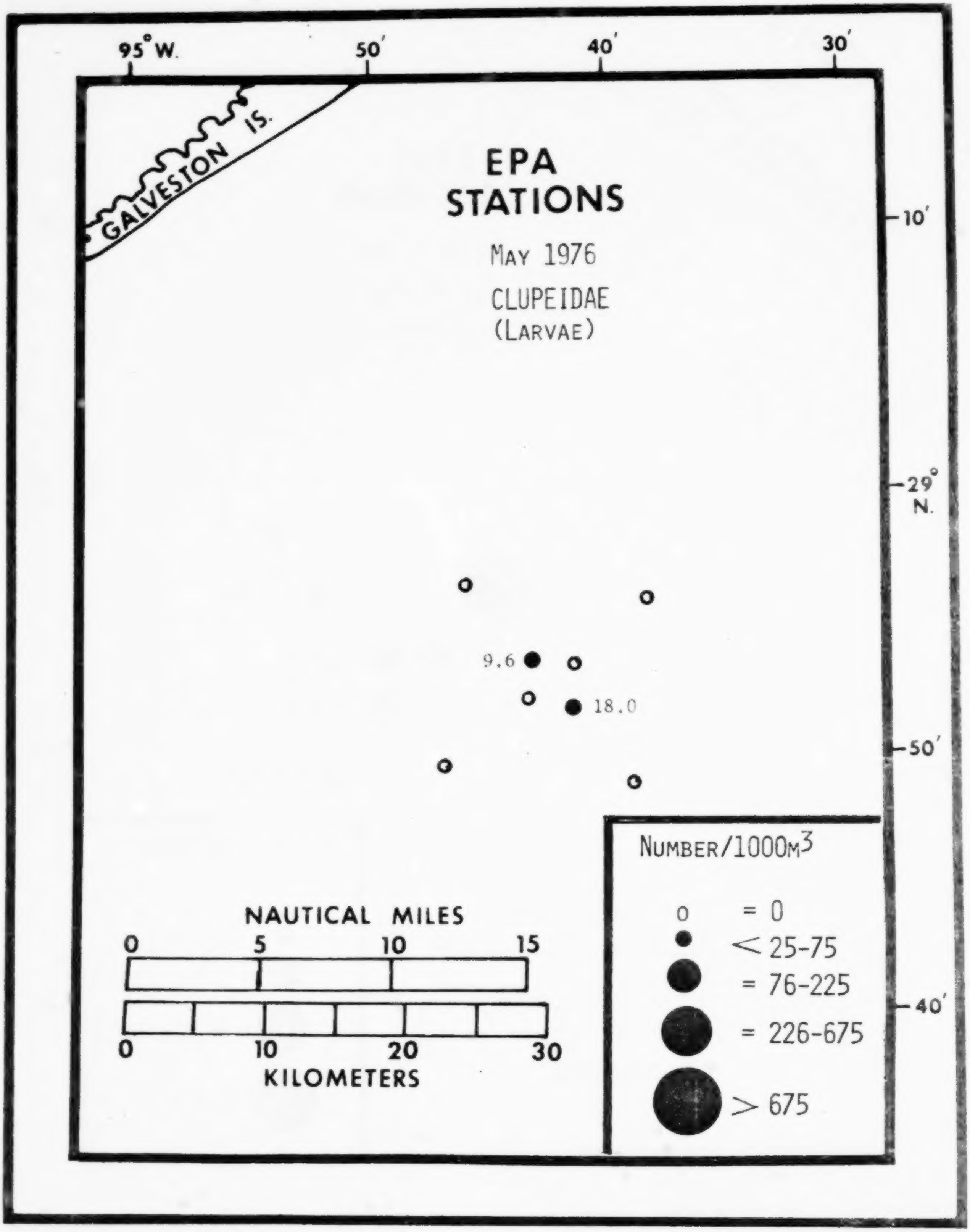

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
MAY 1976
CLUPEIDAE
(LARVAE)
9.6
18.0
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 15. Distribution, abundance and size range (SL) in mm of clupeid larvae in the Buccaneer oil field area during May 1976.

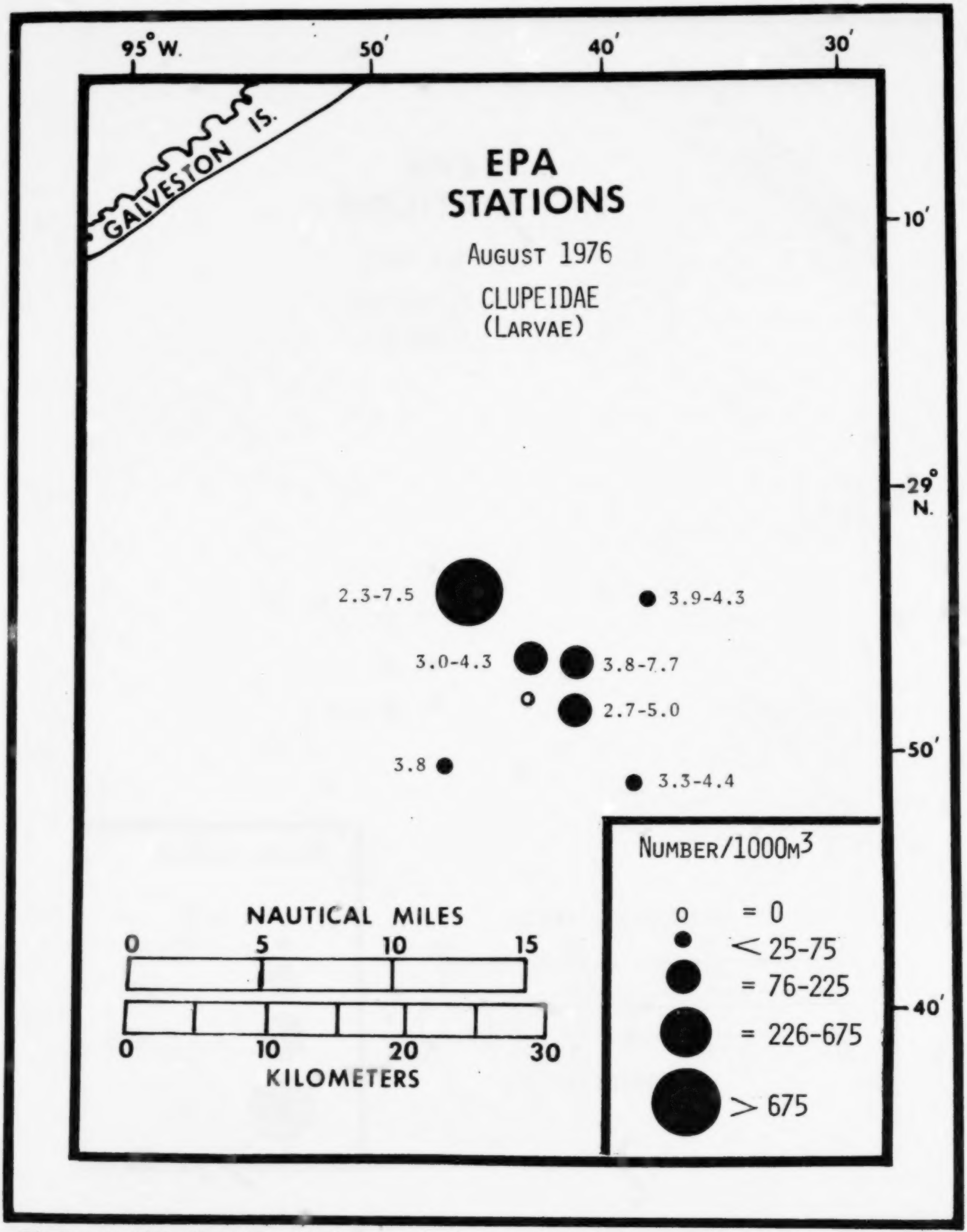

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
AUGUST 1976
CLUPEIDAE (LARVAE)
2.3-7.5
3.9-4.3
3.0-4.3
3.8-7.7
2.7-5.0
3.8
3.3-4.4
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 16. Distribution, abundance and size range (SL) in mm of clupeid larvae in the Buccaneer oil field area during August 1976.

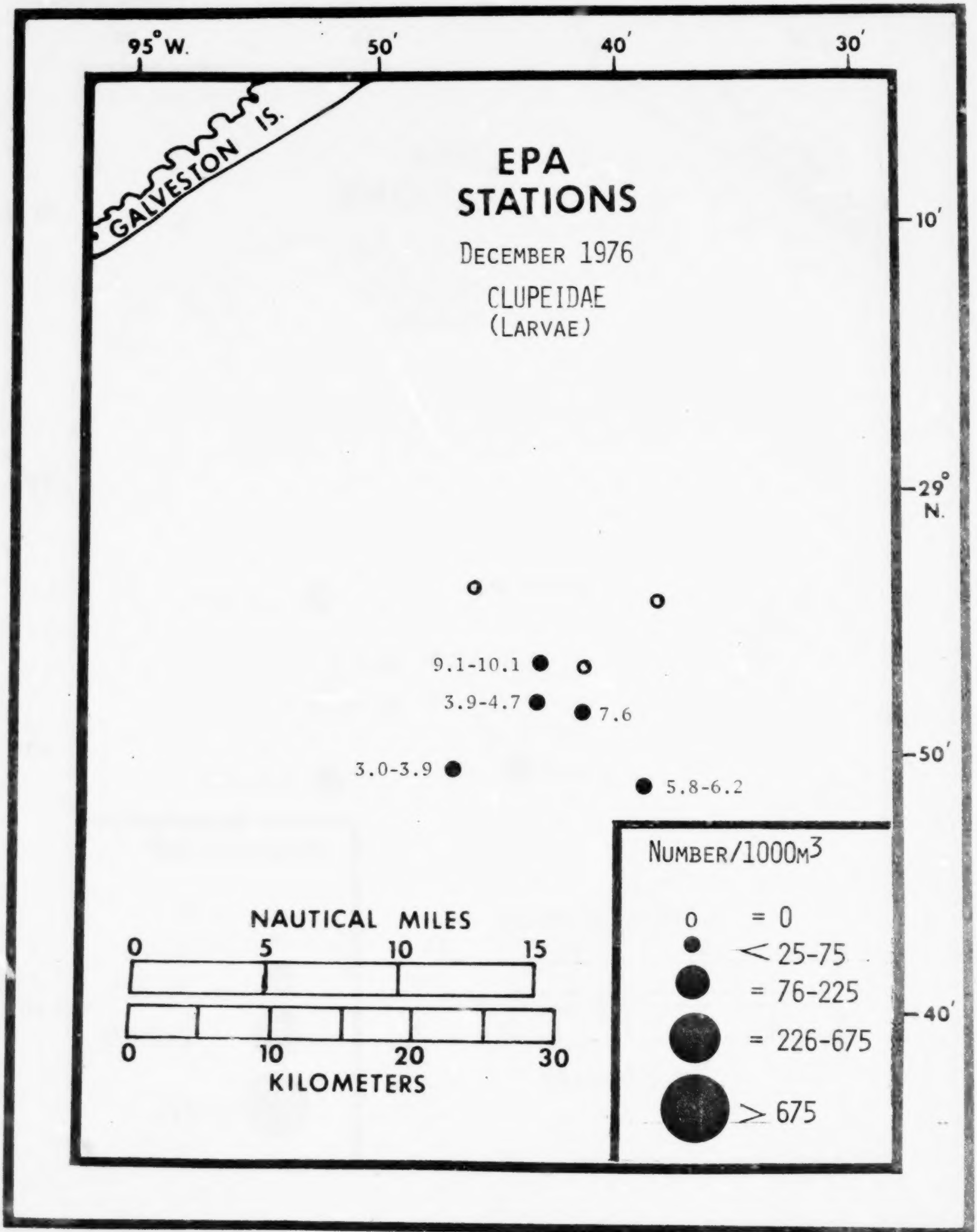

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
CLUPEIDAE
(LARVAE)
10′
29° N.
50′
40′
9.1-10.1
3.9-4.7
7.6
3.0-3.9
5.8-6.2
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
0 = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 17. Distribution, abundance and size range (SL) in mm of clupeid larvae in the Buccaneer oil field area during December 1976.

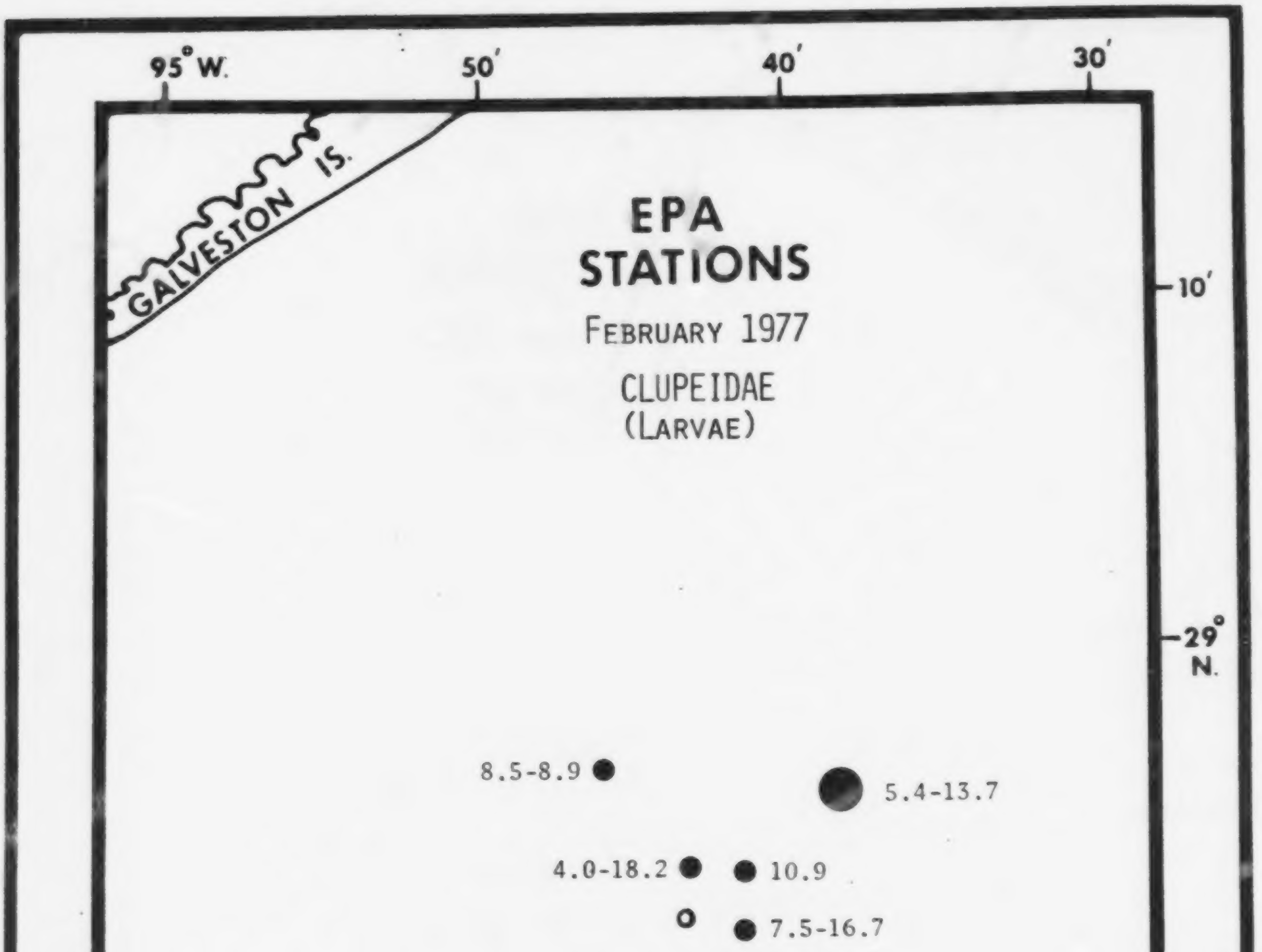

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
FEBRUARY 1977
CLUPEIDAE
(LARVAE)
10′
29° N.
50′
40′
8.5-8.9
5.4-13.7
4.0-18.2
10.9
7.5-16.7
7.0-19.0
6.6-15.5
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
= 0
< 25-75
= 76-225
= 226-675
> 675

Figure 18. Distribution, abundance and size range (SL) in mm of clupeid larvae in the Buccaneer oil field area during February 1977.

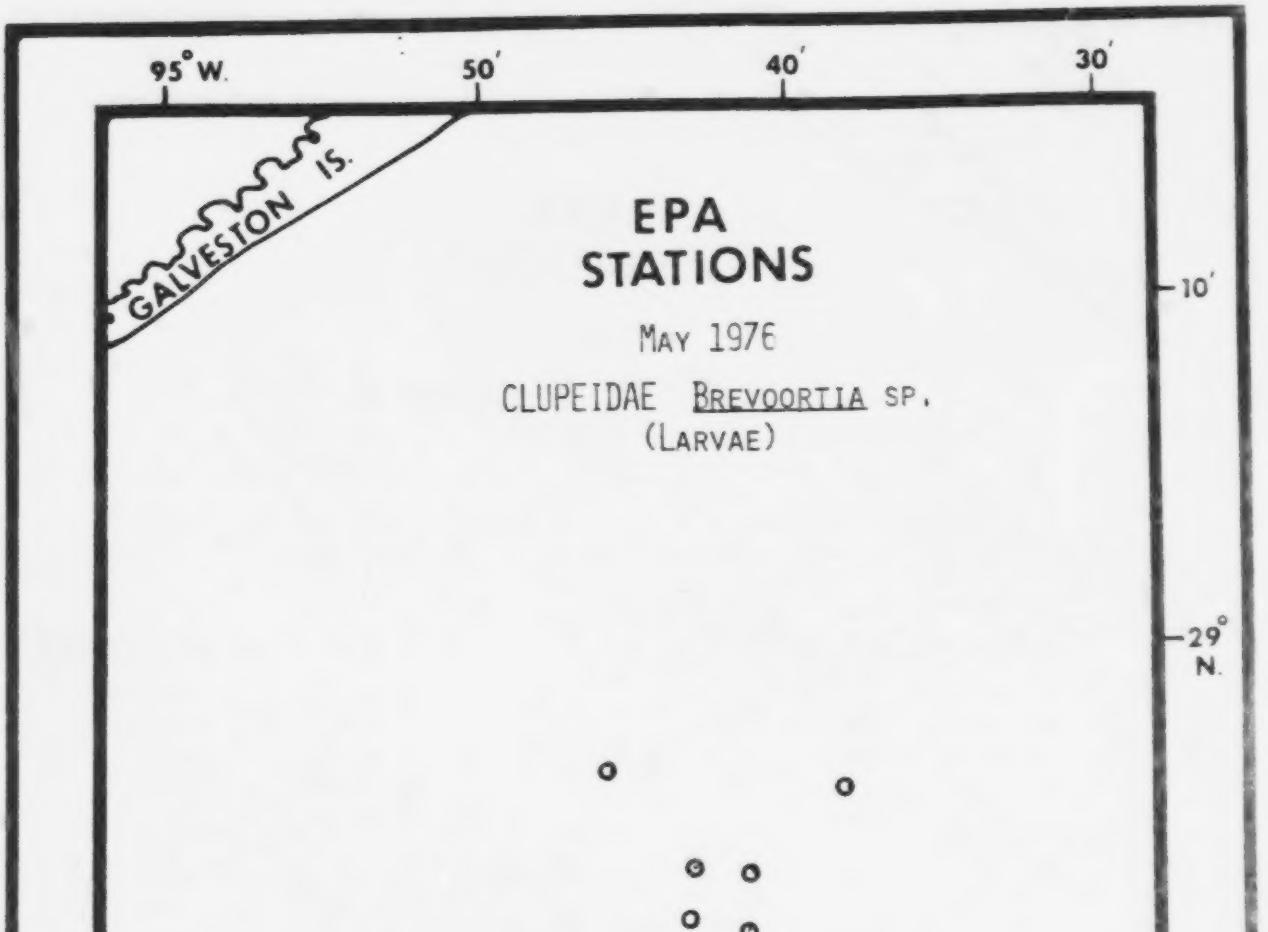

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
MAY 1976
CLUPEIDAE BREVOORTIA SP.
(LARVAE)
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M^3
0 = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 19. Distribution, abundance and size range (SL) in mm of *Brevoortia* sp. larvae in the Buccaneer oil field area during May 1976.

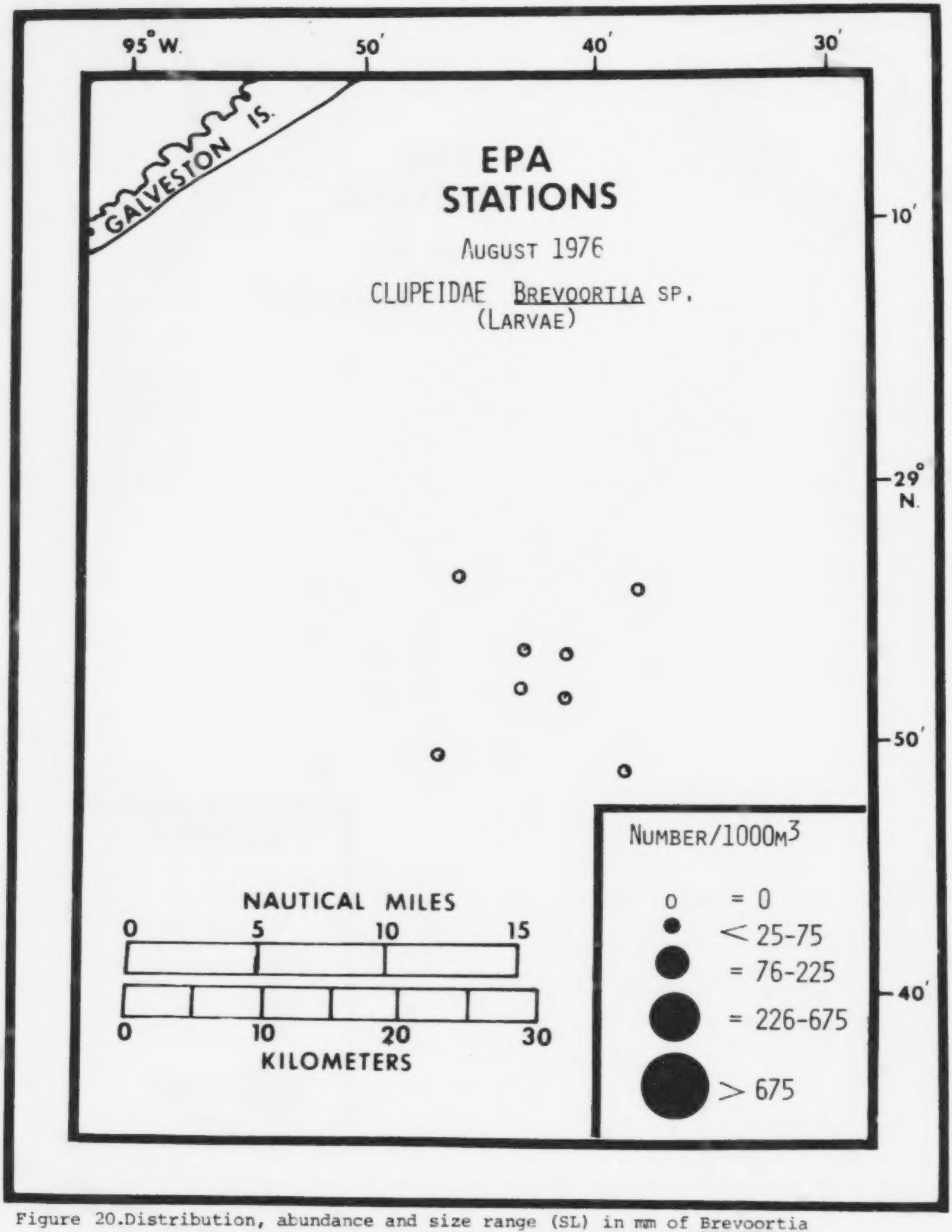

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
AUGUST 1976
CLUPEIDAE BREVOORTIA SP.
(LARVAE)
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 20.Distribution, abundance and size range (SL) in mm of *Brevoortia* sp. larvae in the Buccaneer oil field area during August 1976.

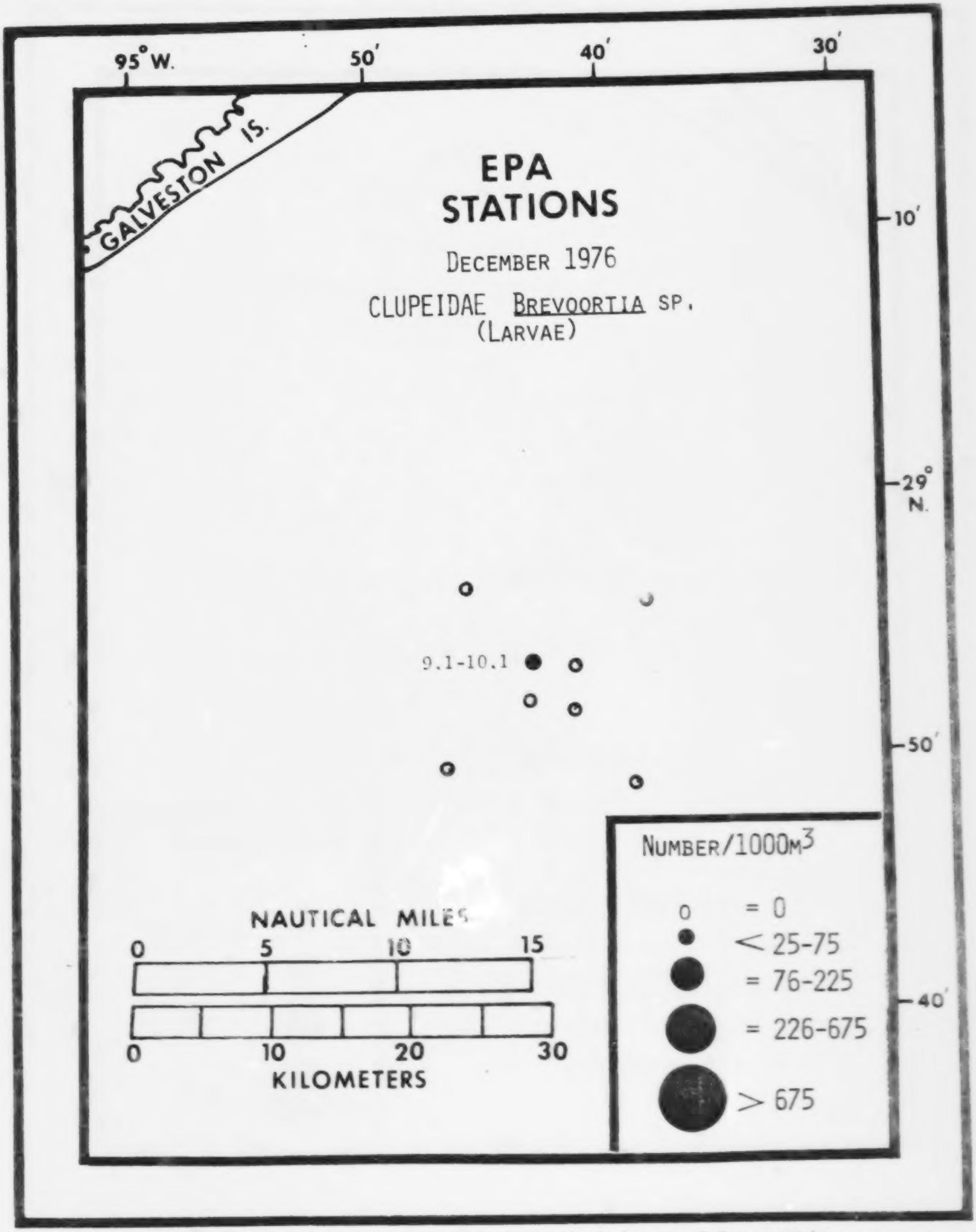

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
CLUPEIDAE Brevoortia SP.
(LARVAE)
9.1-10.1
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
• < 25-75
● = 76-225
● = 226-675
● > 675

Figure 21. Distribution, abundance and size range (SL) in mm of *Brevoortia* sp. larvae in the Buccaneer oil field area during December 1976.

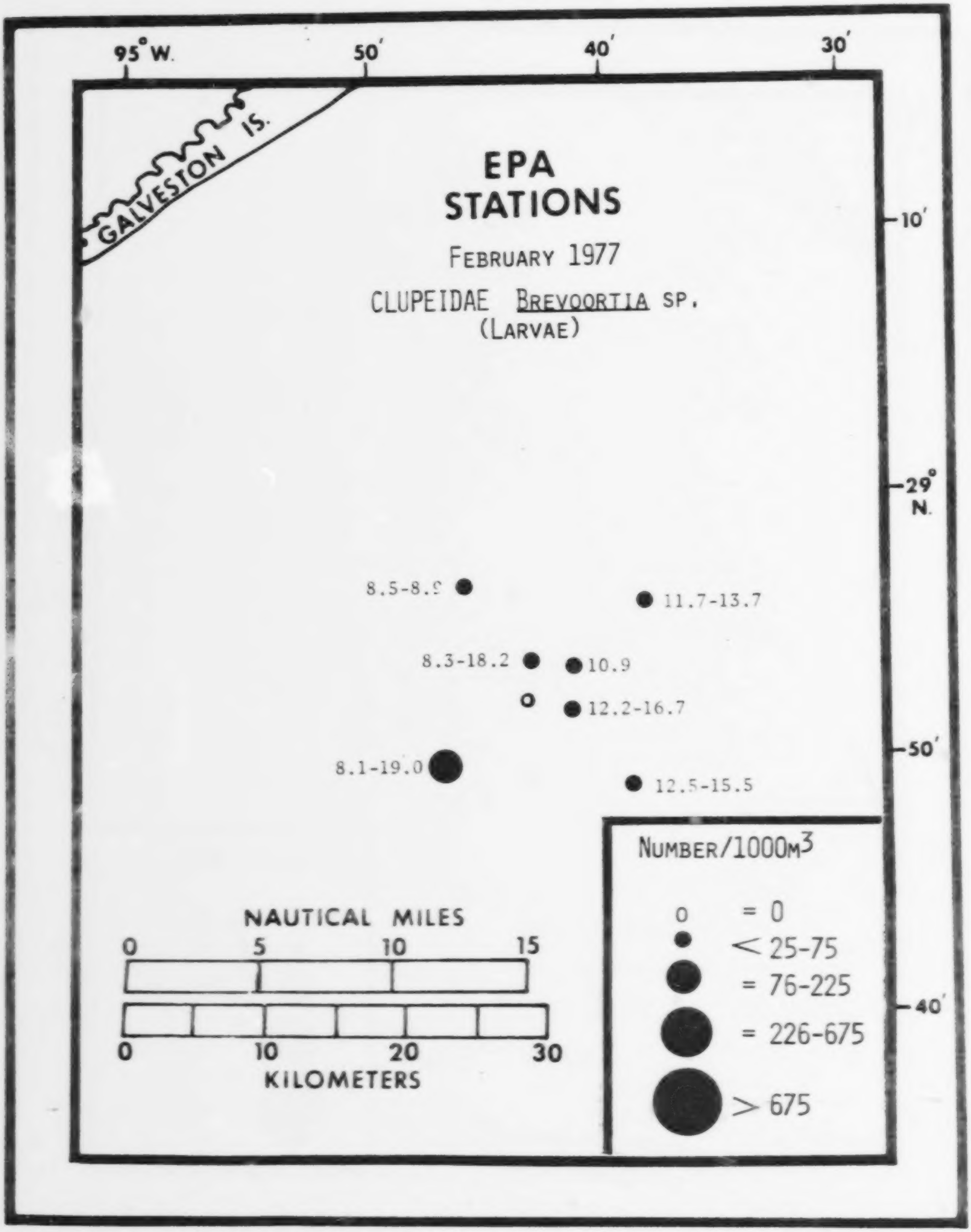
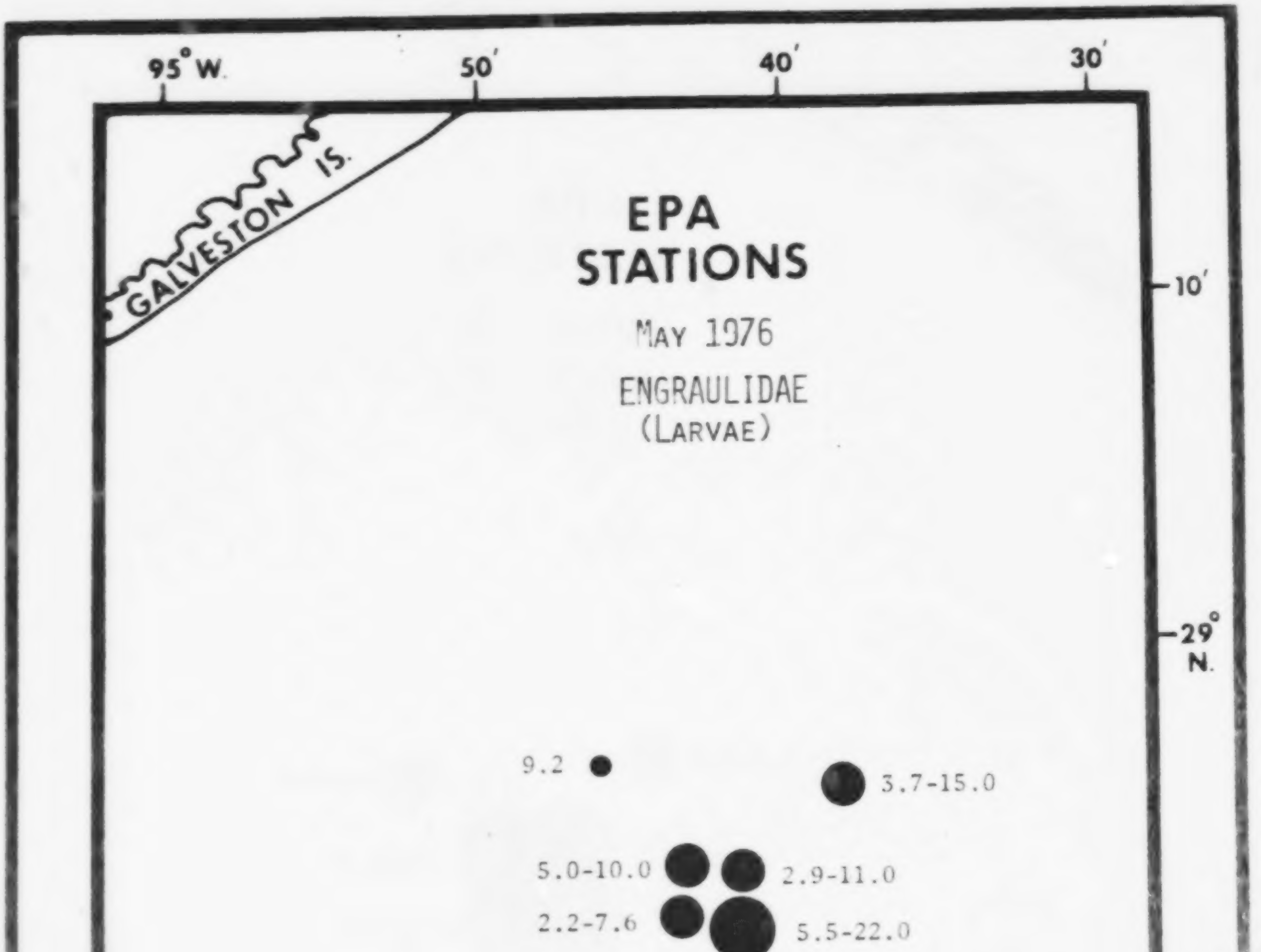

95°W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
CLUPEIDAE Brevoortia SP.
(LARVAE)
8.5-8.9
11.7-13.7
8.3-18.2
10.9
12.2-16.7
8.1-19.0
12.5-15.5
NUMBER/1000M3
o = 0
< 25-75
= 76-225
= 226-675
> 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 22. Distribution, abundance and size range (SL) in mm of *Brevoortia* sp. larvae in the Buccaneer oil field area during February 1977.



95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
MAY 1976
ENGRAULIDAE
(LARVAE)
9.2
3.7-15.0
5.0-10.0
2.9-11.0
2.2-7.6
5.5-22.0
2.6-4.9
6.5-20.2
NUMBER/1000M3
0 = 0
< 25-75
= 76-225
= 226-675
> 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 23. Distribution, abundance and size range (SL) in mm of engraulid larvae in the Buccaneer oil field area during May 1976.

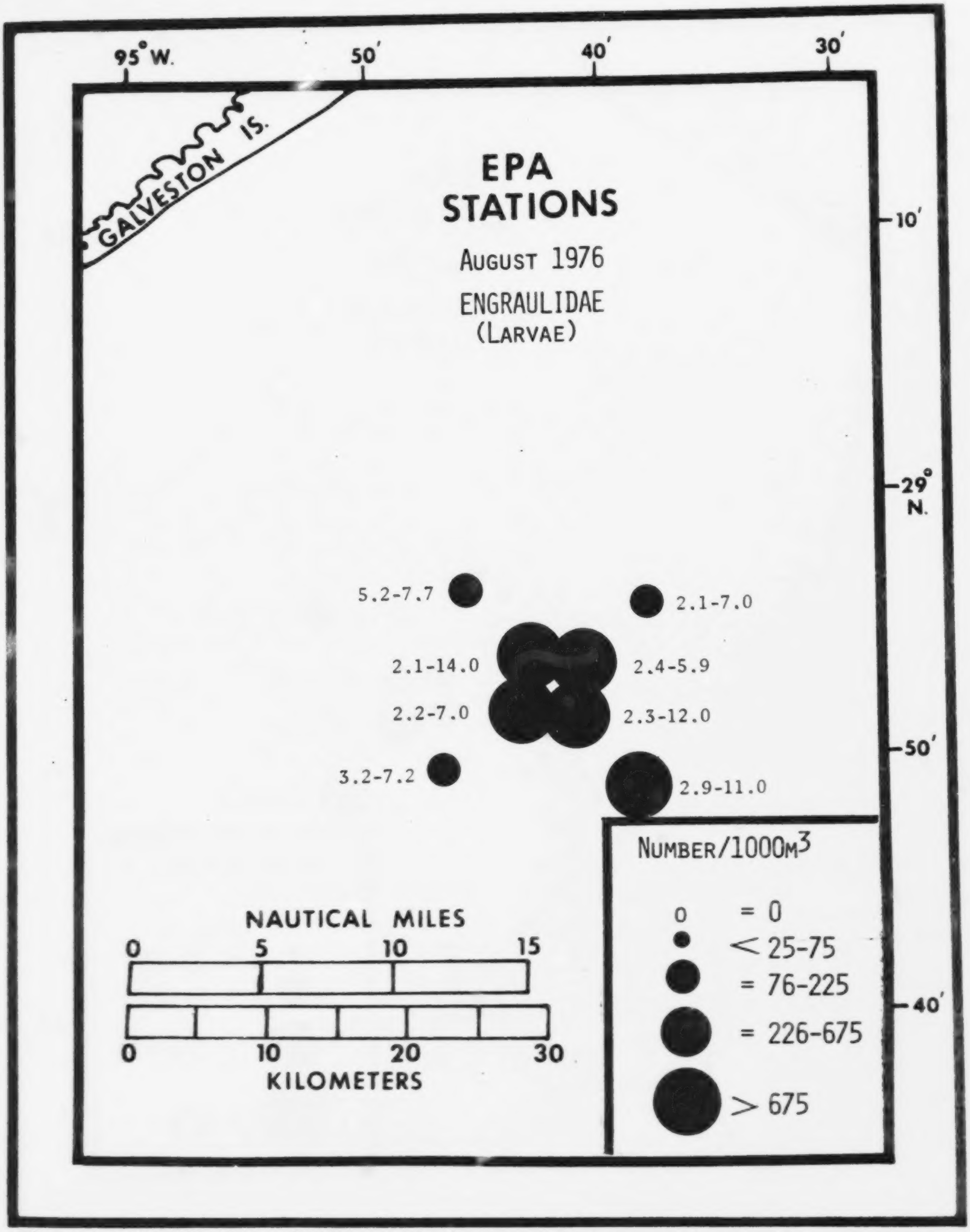

95° W.
50'
40'
30'
GALVESTON IS.
EPA STATIONS
AUGUST 1976
ENGRAULIDAE
(LARVAE)
10'
29° N.
50'
40'
5.2-7.7
2.1-7.0
2.1-14.0
2.4-5.9
2.2-7.0
2.3-12.0
3.2-7.2
2.9-11.0
NUMBER/1000M3
0 = 0
< 25-75
= 76-225
= 226-675
> 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 24. Distribution, abundance and size range (SL) in mm of engraulid larvae in the Buccaneer oil field area during August 1976.

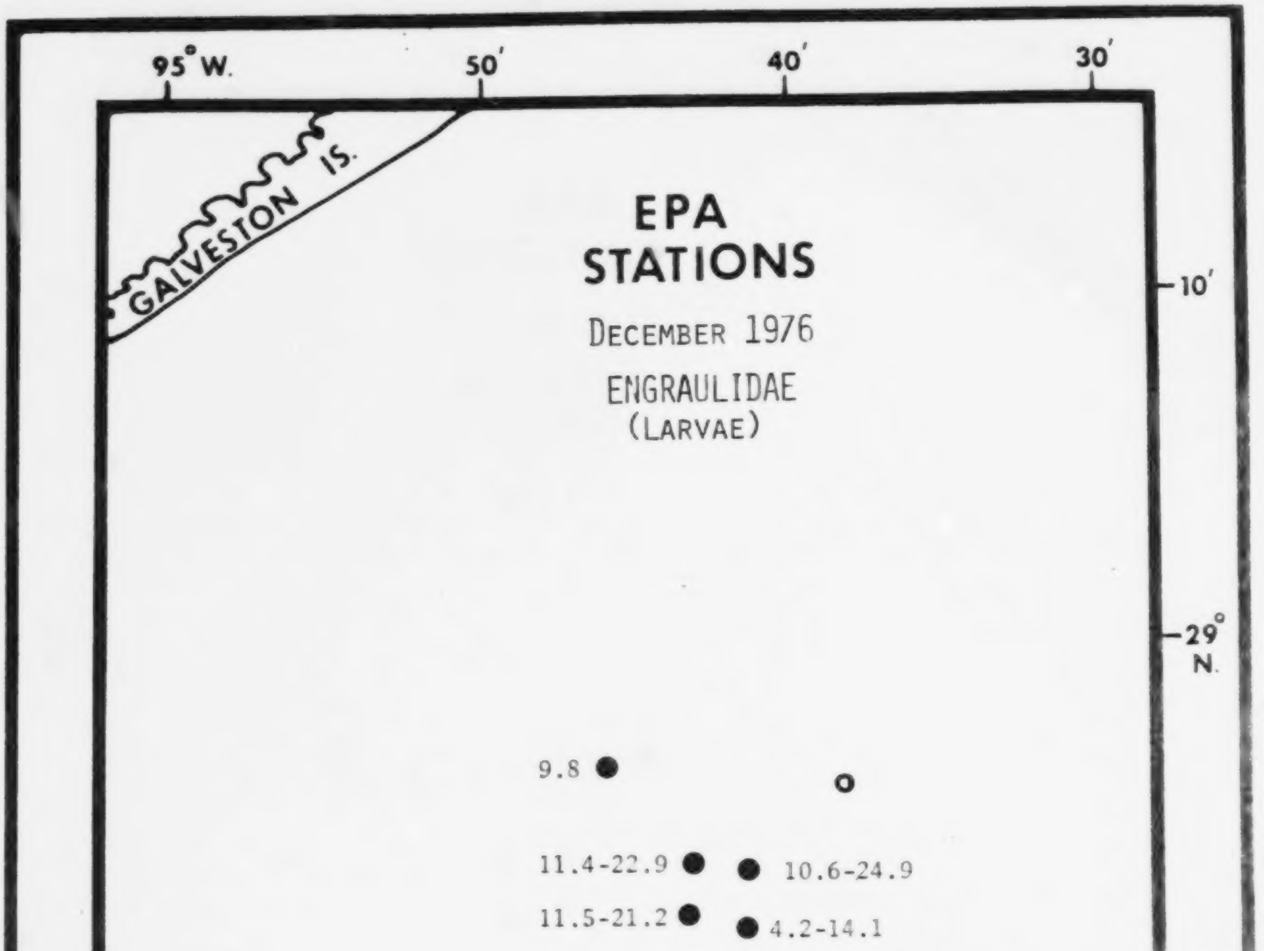

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
December 1976
ENGRAULIDAE
(Larvae)
9.8
11.4-22.9
10.6-24.9
11.5-21.2
4.2-14.1
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
Number/1000m3
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 25. Distribution, abundance and size range (SL) in mm of engraulid larvae in the Buccaneer oil field area during December 1976.

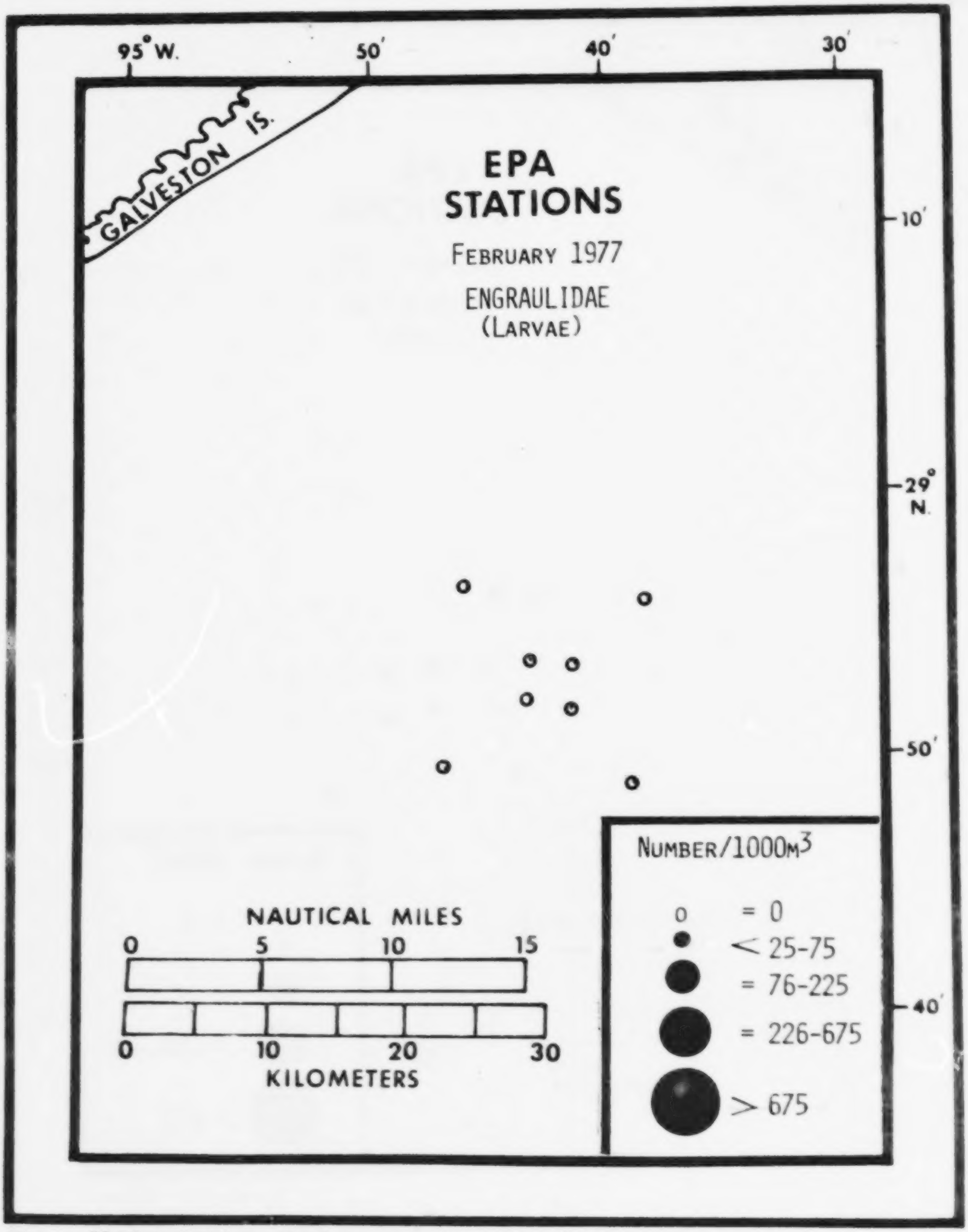

95° W.
50'
40'
30'
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
ENGRAULIDAE (LARVAE)
10'
29° N.
50'
40'
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M³
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 26. Distribution, abundance and size range (SL) in mm of engraulid larvae in the Buccaneer oil field area during February 1977.

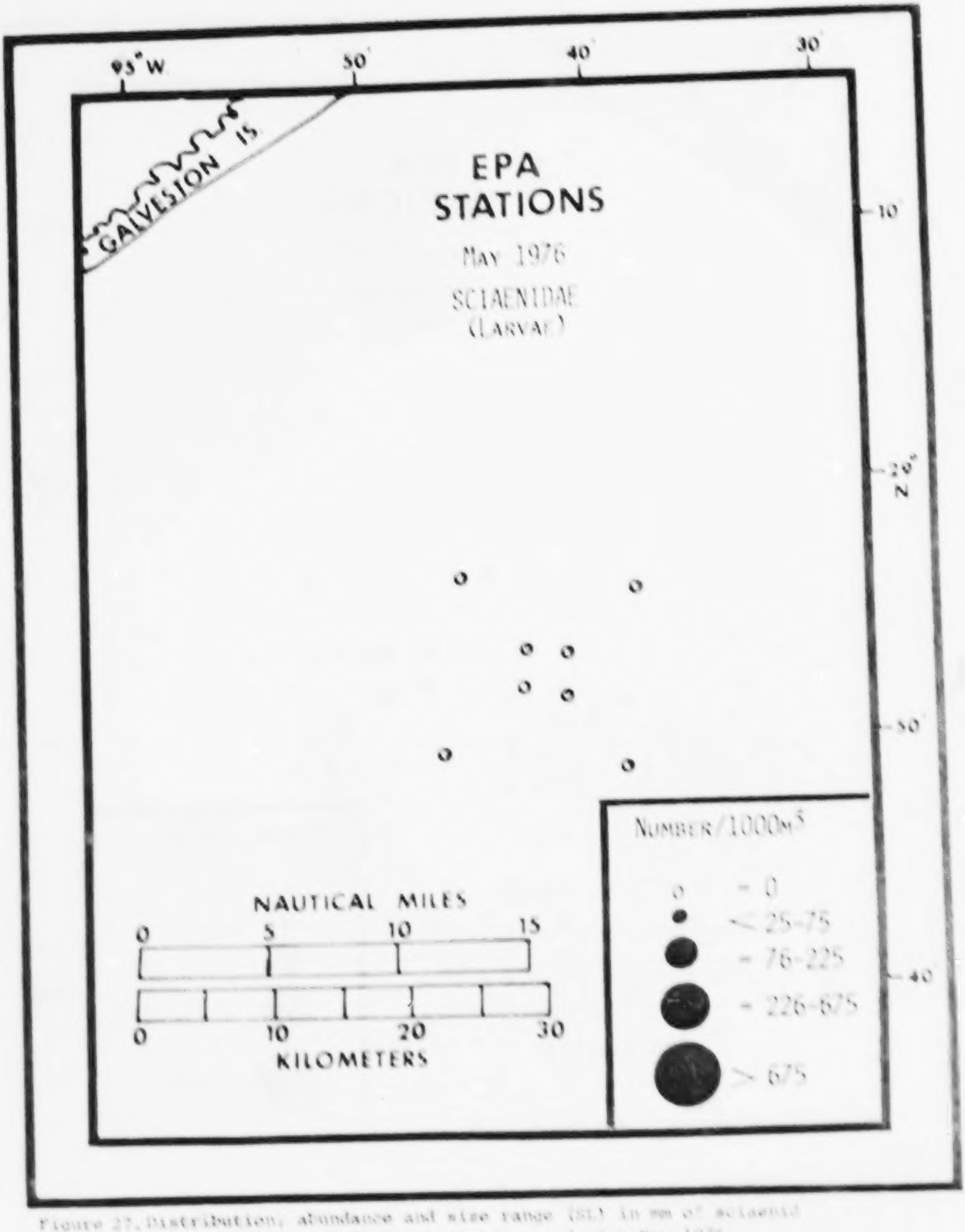

95° W
50'
40'
30'
10'
20'
N
50'
40'
GALVESTON IS
EPA
STATIONS
MAY 1976
SCIAENIDAE
(LARVAE)
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M³
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 27. Distribution, abundance and size range (SL) in mm of sciaenid larvae in the Buccaneer oil field area during May 1976.

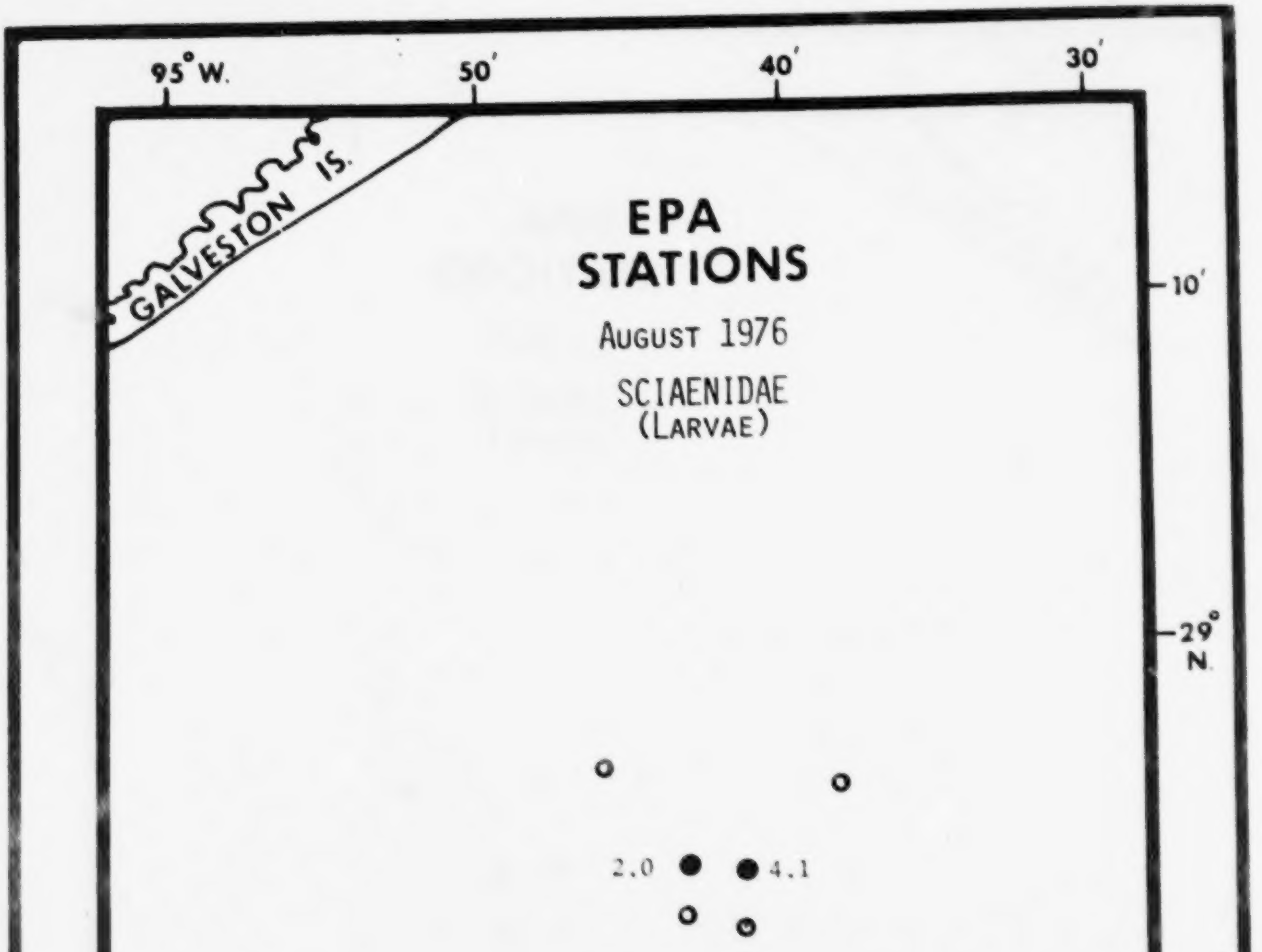

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
August 1976
SCIAENIDAE (Larvae)
2.0
4.1
2.1
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
Number/1000m3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 28. Distribution, abundance and size range (SL) in mm of sciaenid larvae in the Buccaneer oil field area during August 1976.

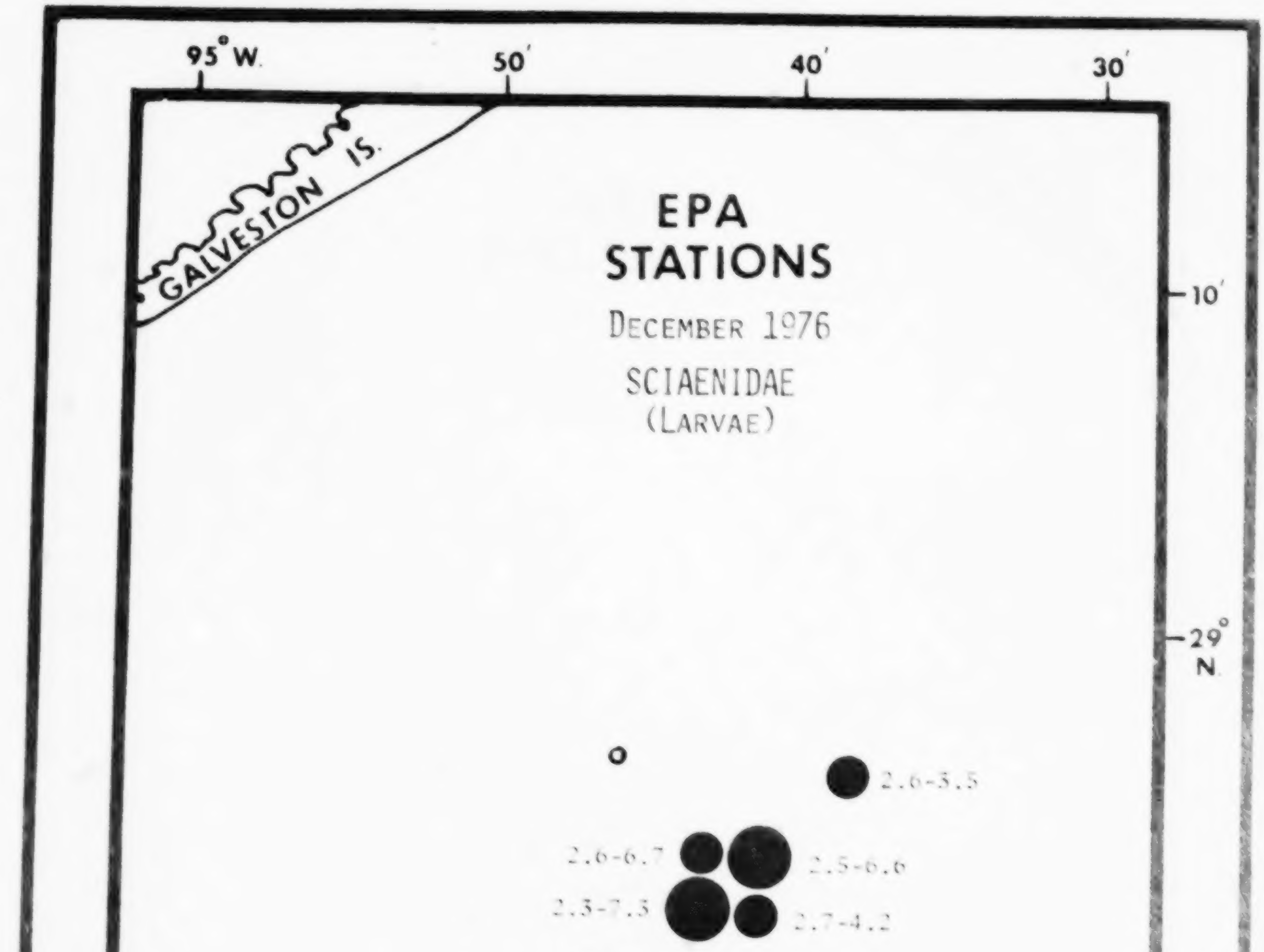

95° W.
50'
40'
30'
GALVESTON IS.
EPA
STATIONS
DECEMBER 1976
SCIAENIDAE
(LARVAE)
10'
29°
N.
50'
40'
0
2.6-3.5
2.6-6.7
2.5-6.6
2.3-7.3
2.7-4.2
2.8-6.9
6.8
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
0 = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 29. Distribution, abundance and size range (SL) in mm of sciaenid larvae in the Buccaneer oil field area during December 1976.

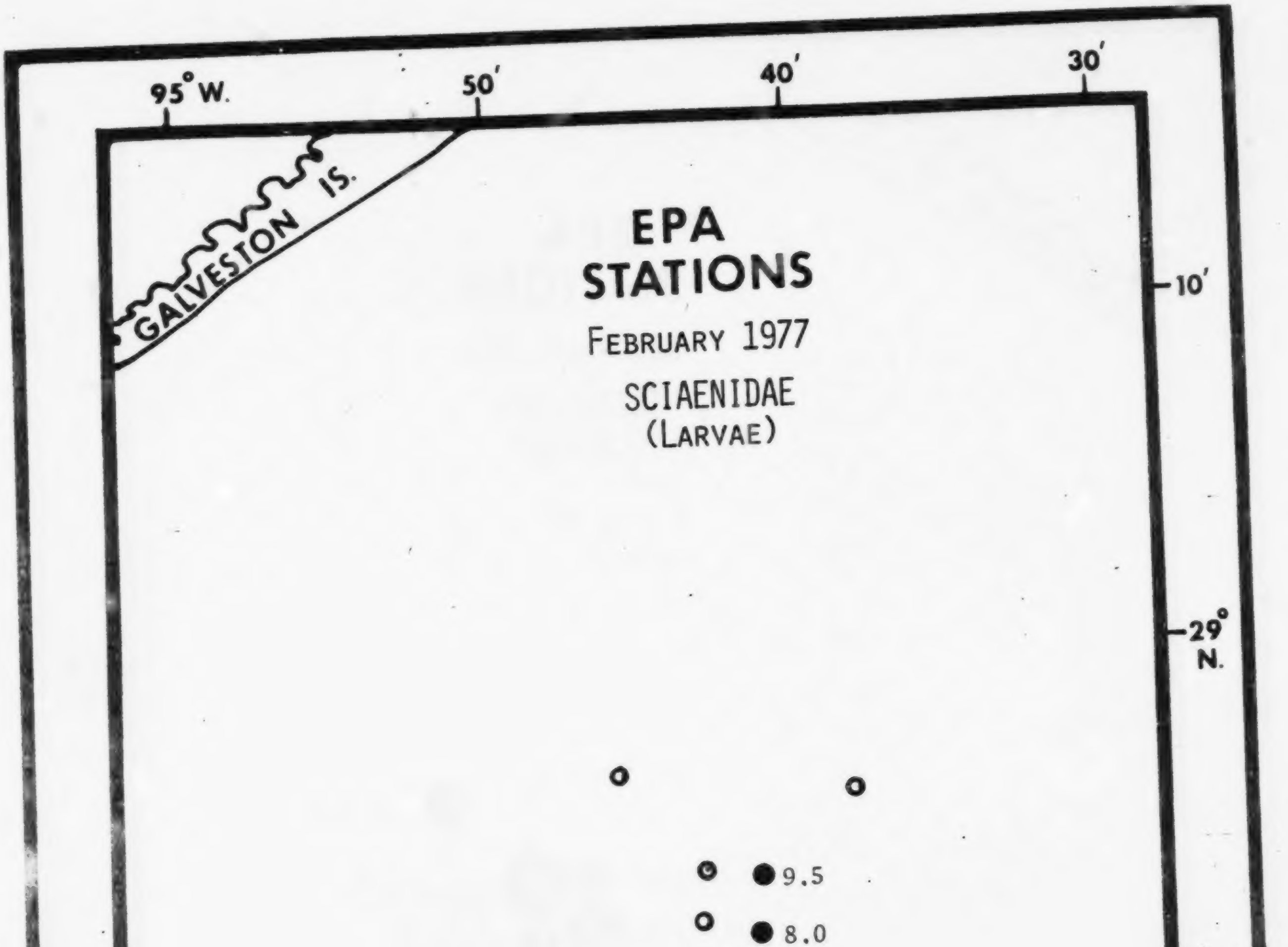

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
SCIAENIDAE
(LARVAE)
9.5
8.0
5.0
8.1
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 30 Distribution, abundance and size range (SL) in mm of sciaenid larvae in the Buccaneer oil field area during February 1977.

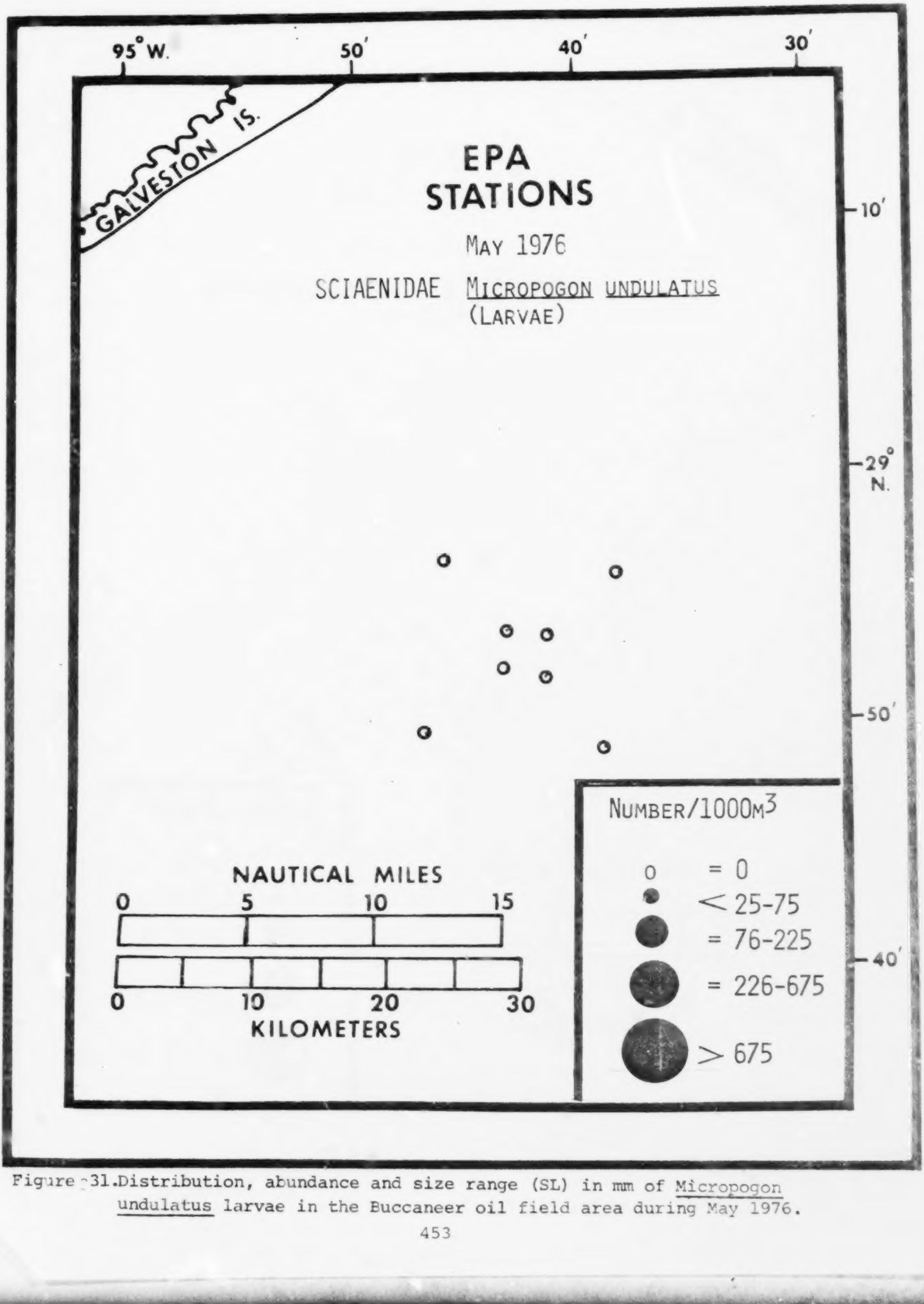

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
MAY 1976
SCIAENIDAE MICROPOGON UNDULATUS
(LARVAE)
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M³
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 31. Distribution, abundance and size range (SL) in mm of *Micropogon undulatus* larvae in the Buccaneer oil field area during May 1976.

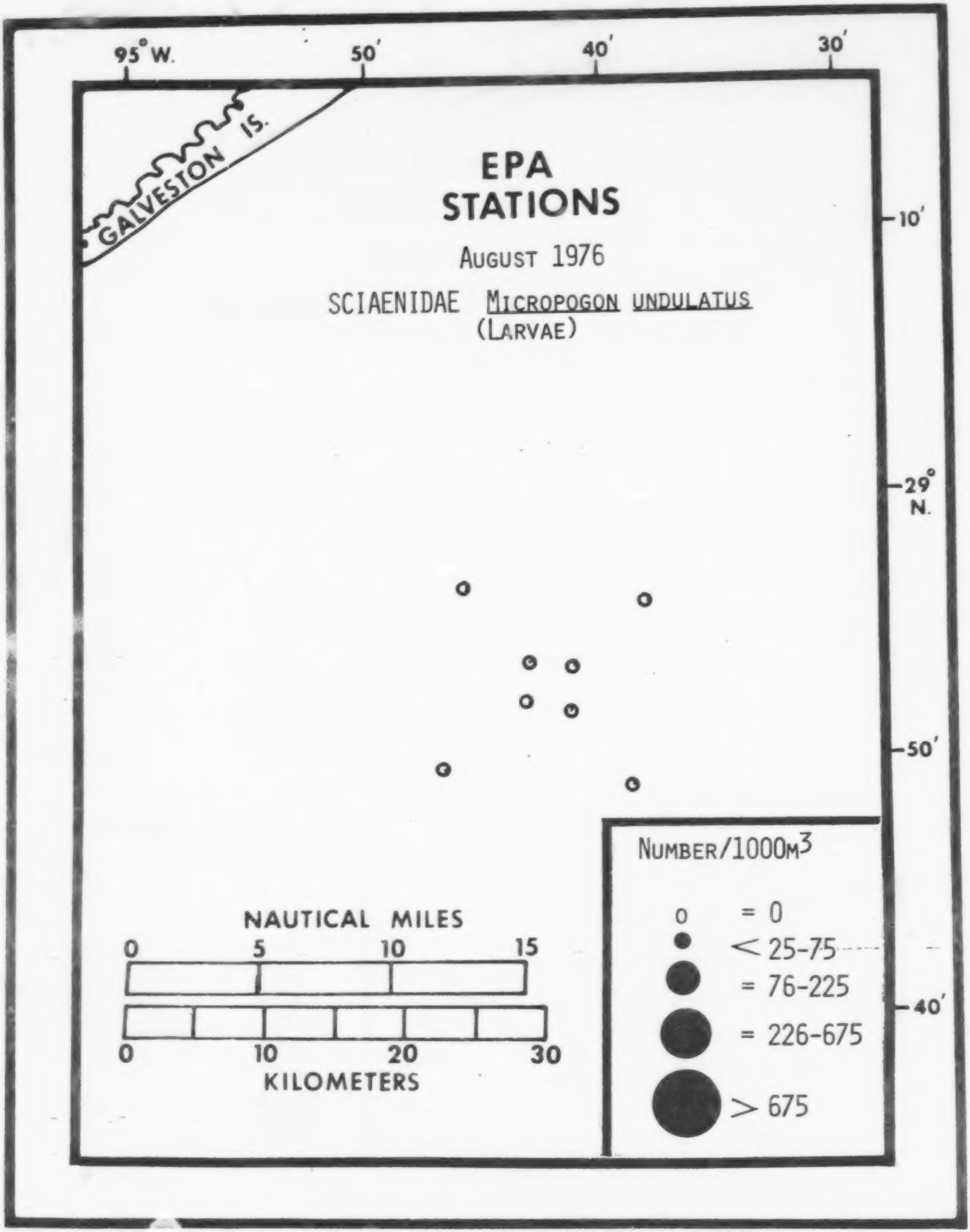

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
AUGUST 1976
SCIAENIDAE MICROPOGON UNDULATUS
(LARVAE)
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 32. Distribution, abundance and size range (SL) in mm of Micropogon undulatus larvae in the Buccaneer oil field area during August 1976.

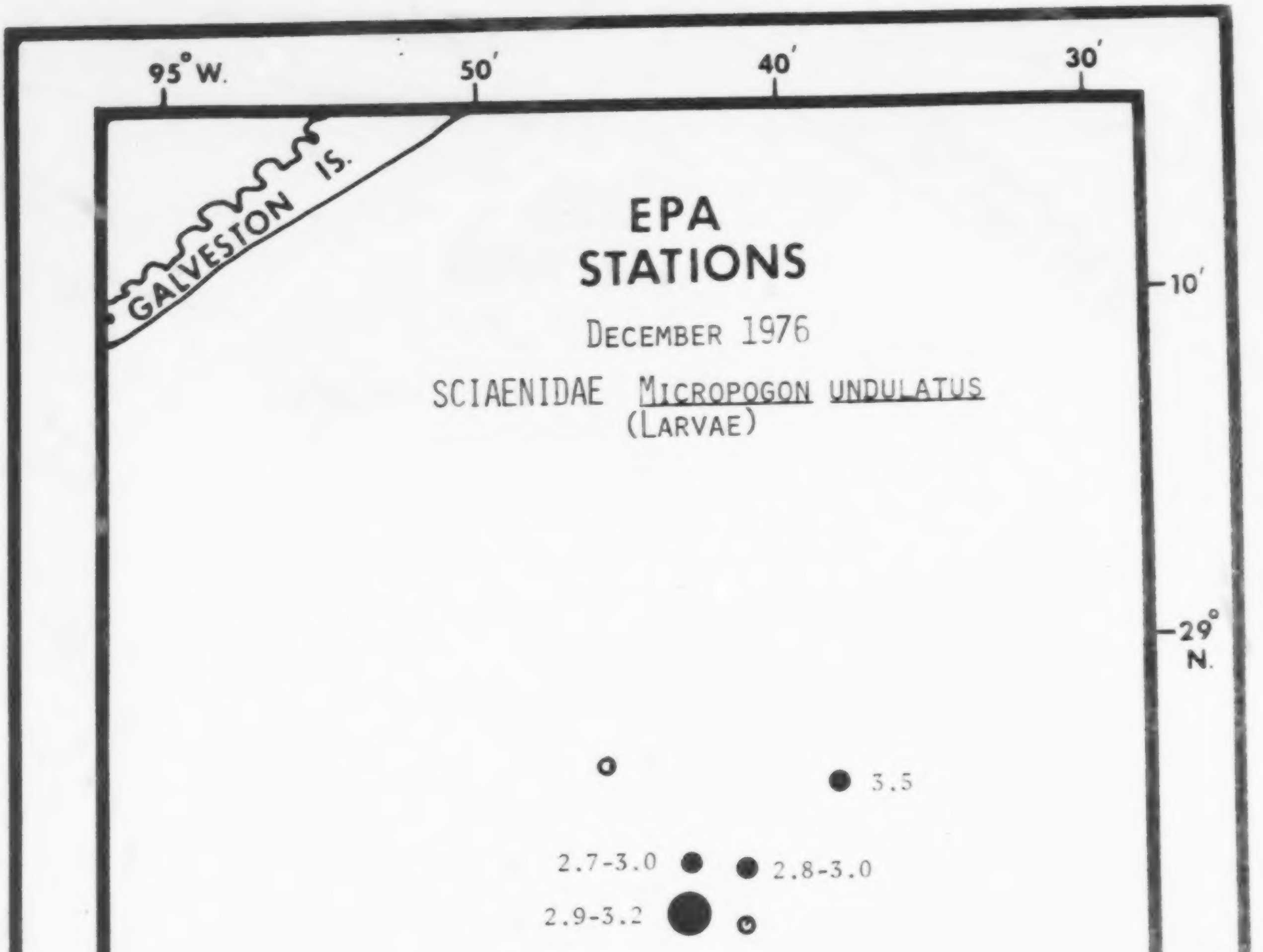

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
SCIAENIDAE Micropogon undulatus
(LARVAE)
3.5
2.7-3.0
2.8-3.0
2.9-3.2
3.0-6.9
NUMBER/1000M3
= 0
< 25-75
= 76-225
= 226-675
> 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 33. Distribution, abundance and size range (SL) in mm of *Micropogon undulatus* larvae in the Buccaneer oil field area during December 1976.

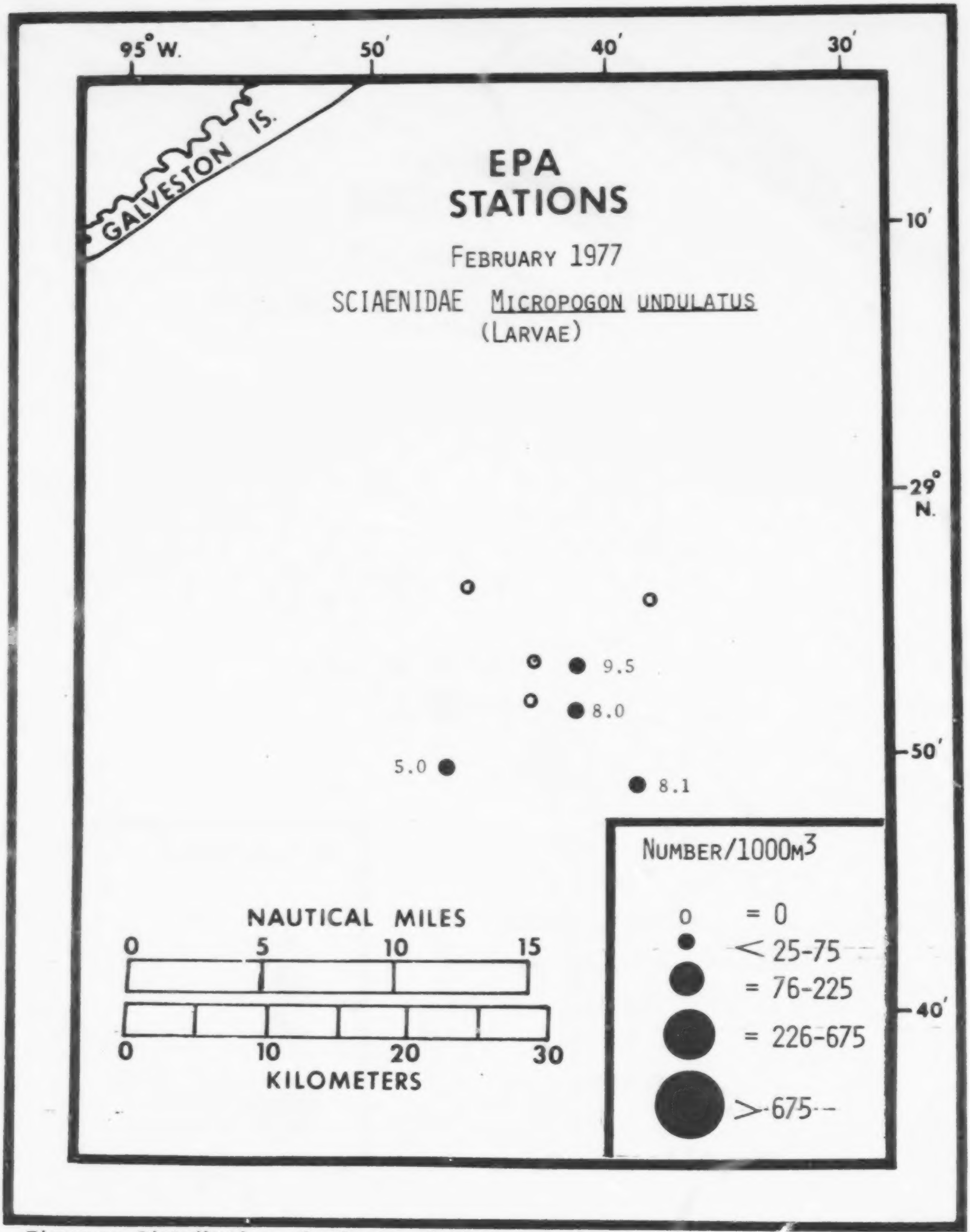

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
SCIAENIDAE MICROPOGON UNDULATUS
(LARVAE)
9.5
8.0
5.0
8.1
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0 5 10 15
0 10 20 30
KILOMETERS

Figure 34. Distribution, abundance and size range (SL) in mm of Micropogon undulatus larvae in the Buccaneer oil field area during February 1977.

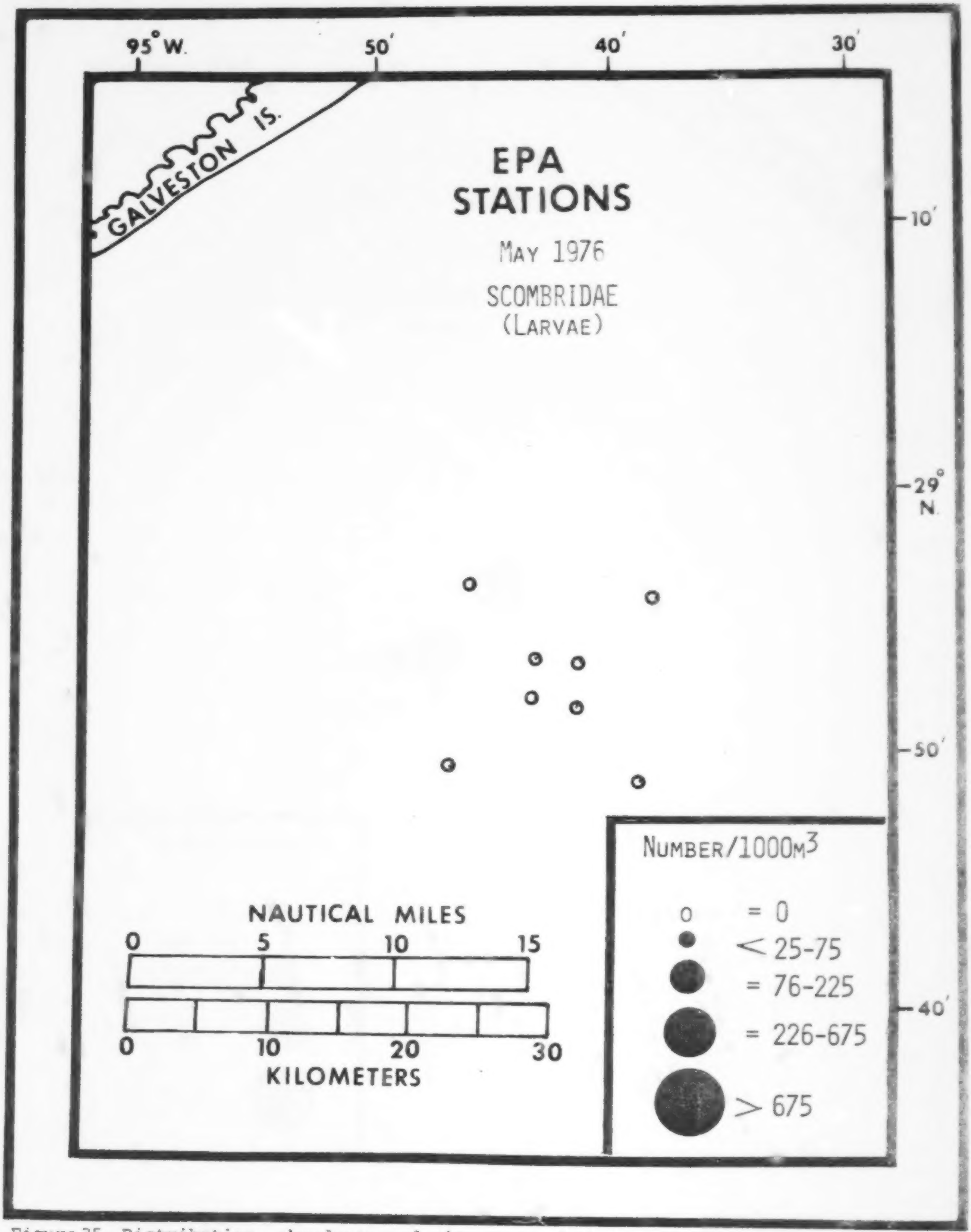

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
May 1976
SCOMBRIDAE
(Larvae)
10′
29°
N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
Number/1000m3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 35, Distribution, abundance and size range (SL) in mm of scombrid larvae in the Buccaneer oil field area during May 1976.

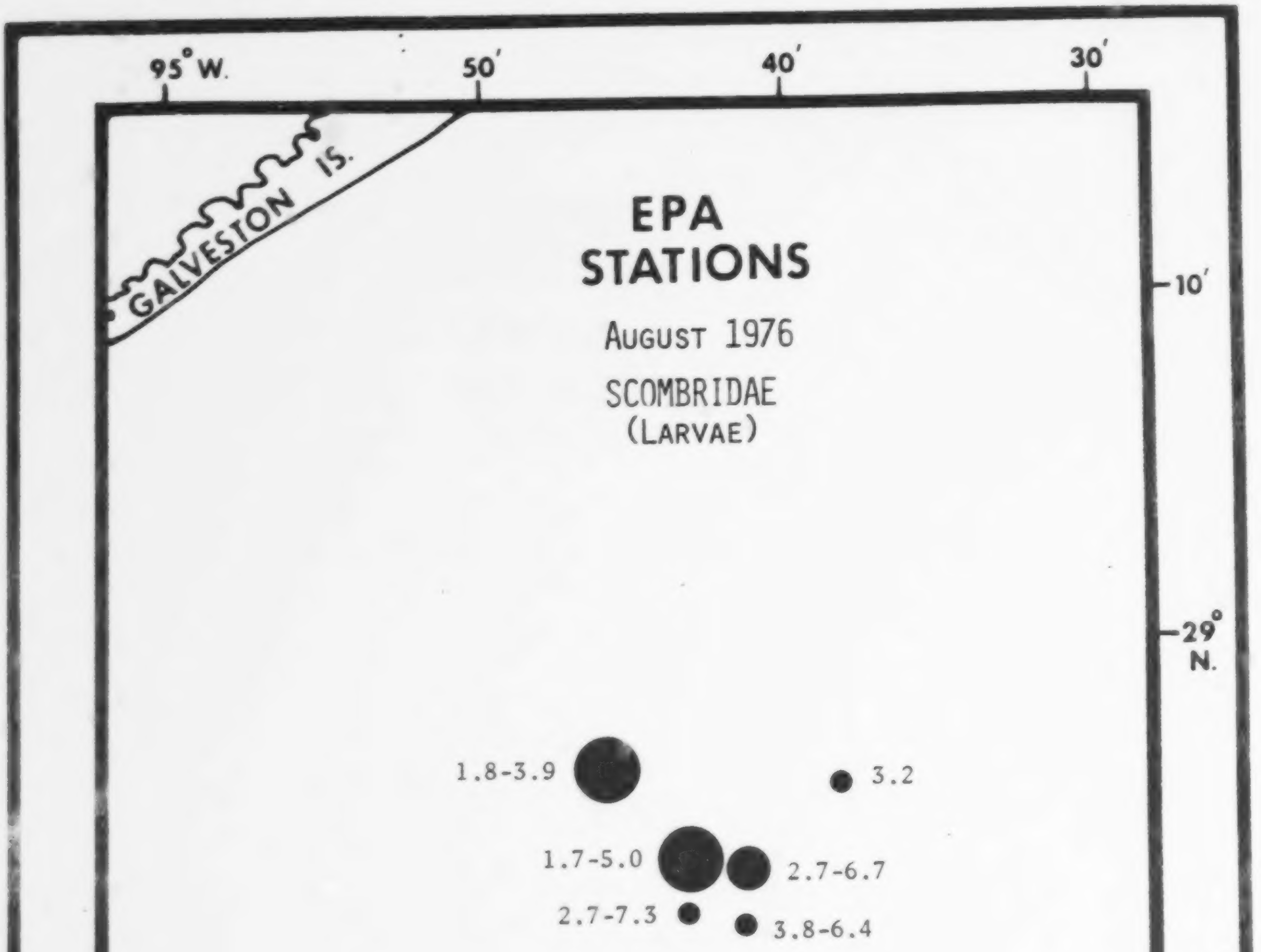

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
August 1976
SCOMBRIDAE
(Larvae)
1.8-3.9
3.2
1.7-5.0
2.7-6.7
2.7-7.3
3.8-6.4
2.1-4.3
2.7
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
Number/1000m3
0 = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 36.Distribution, abundance and size range (SL) in mm of scombrid larvae in the Buccaneer oil field area during August 1976.

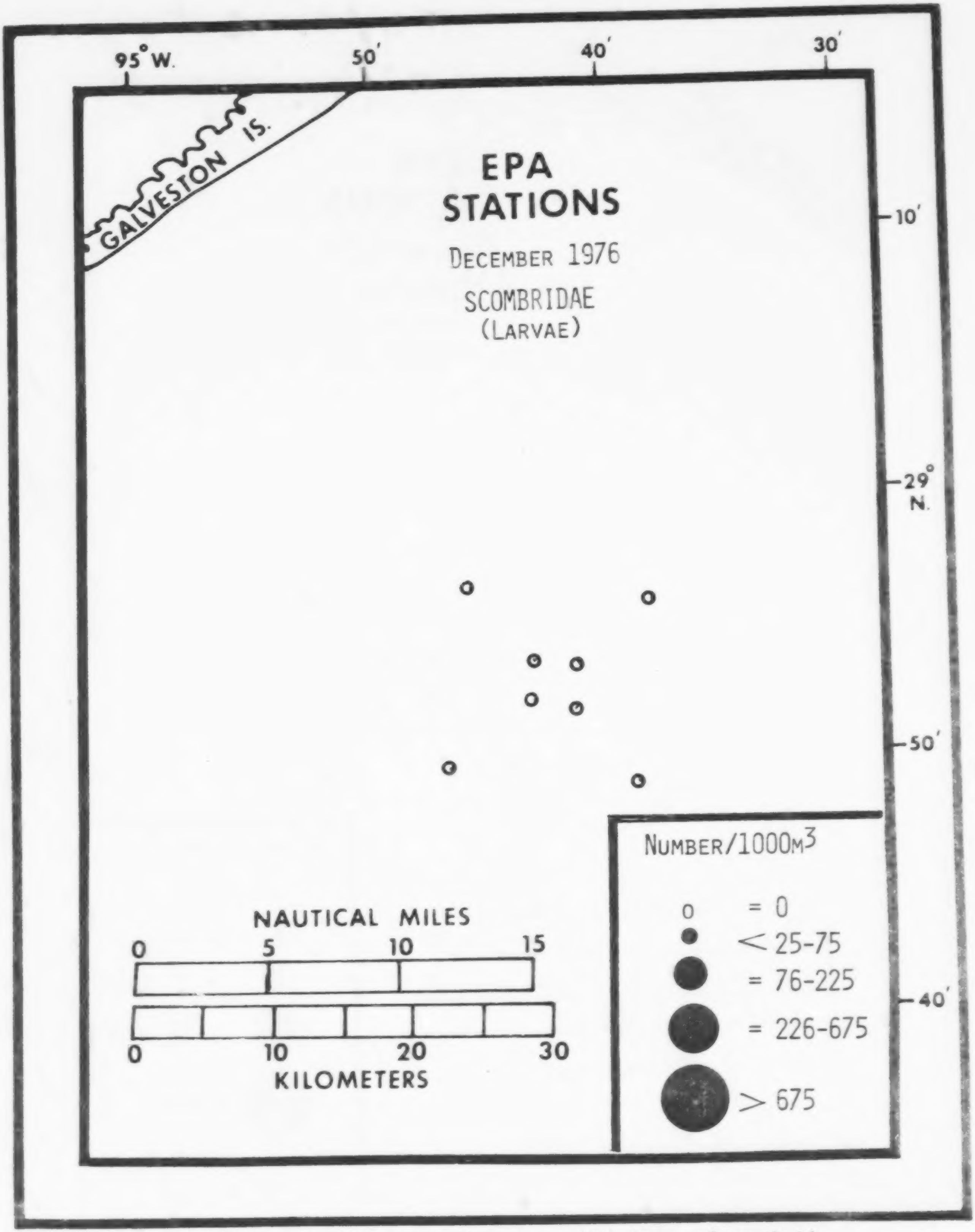

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
SCOMBRIDAE
(LARVAE)
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 37. Distribution, abundance and size range (SL) in mm of scombrid larvae in the Buccaneer oil field area during December 1976.

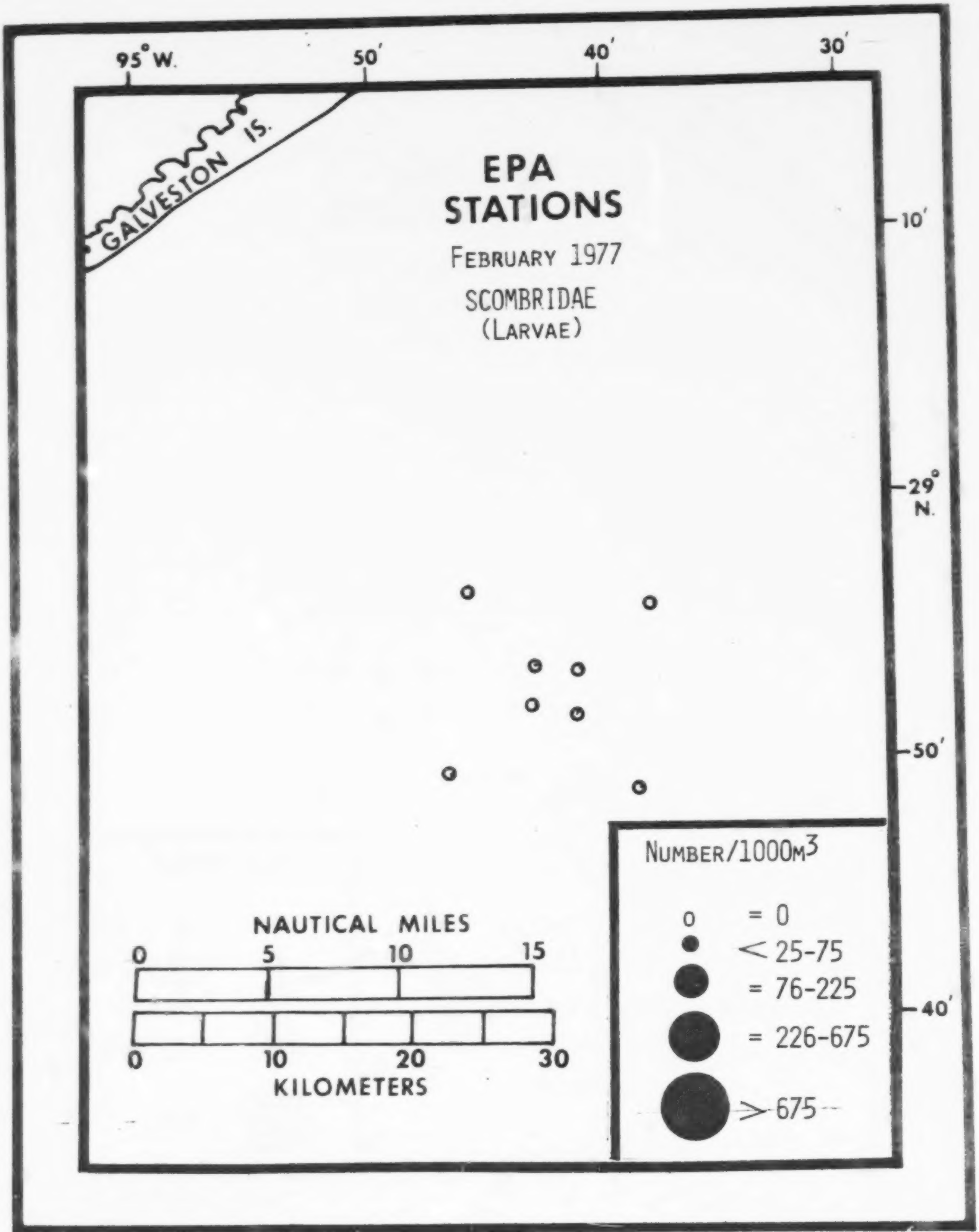

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
SCOMBRIDAE
(LARVAE)
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 38. Distribution, abundance and size range (SL) in mm of scombrid larvae in the Buccaneer oil field area during February 1977.

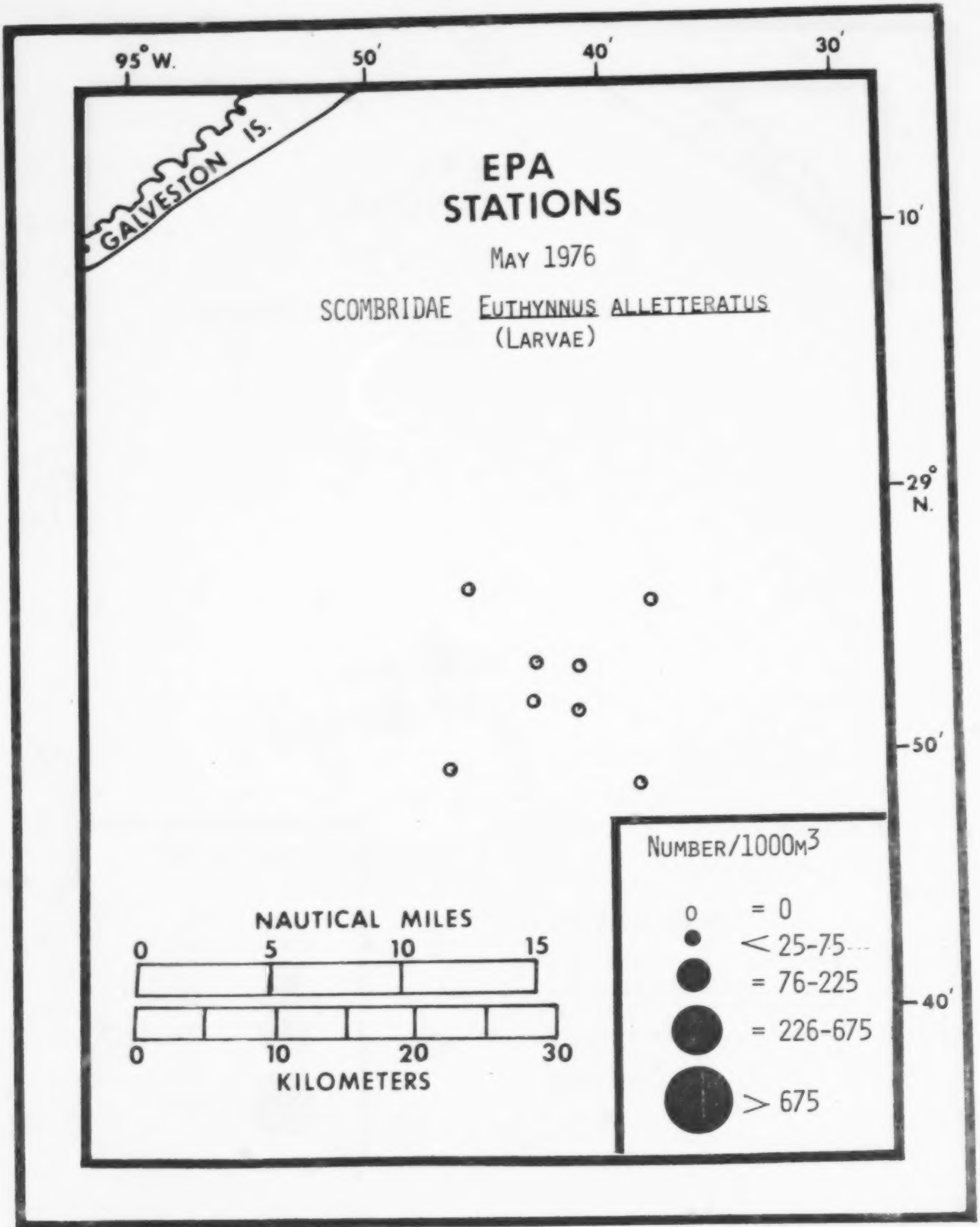
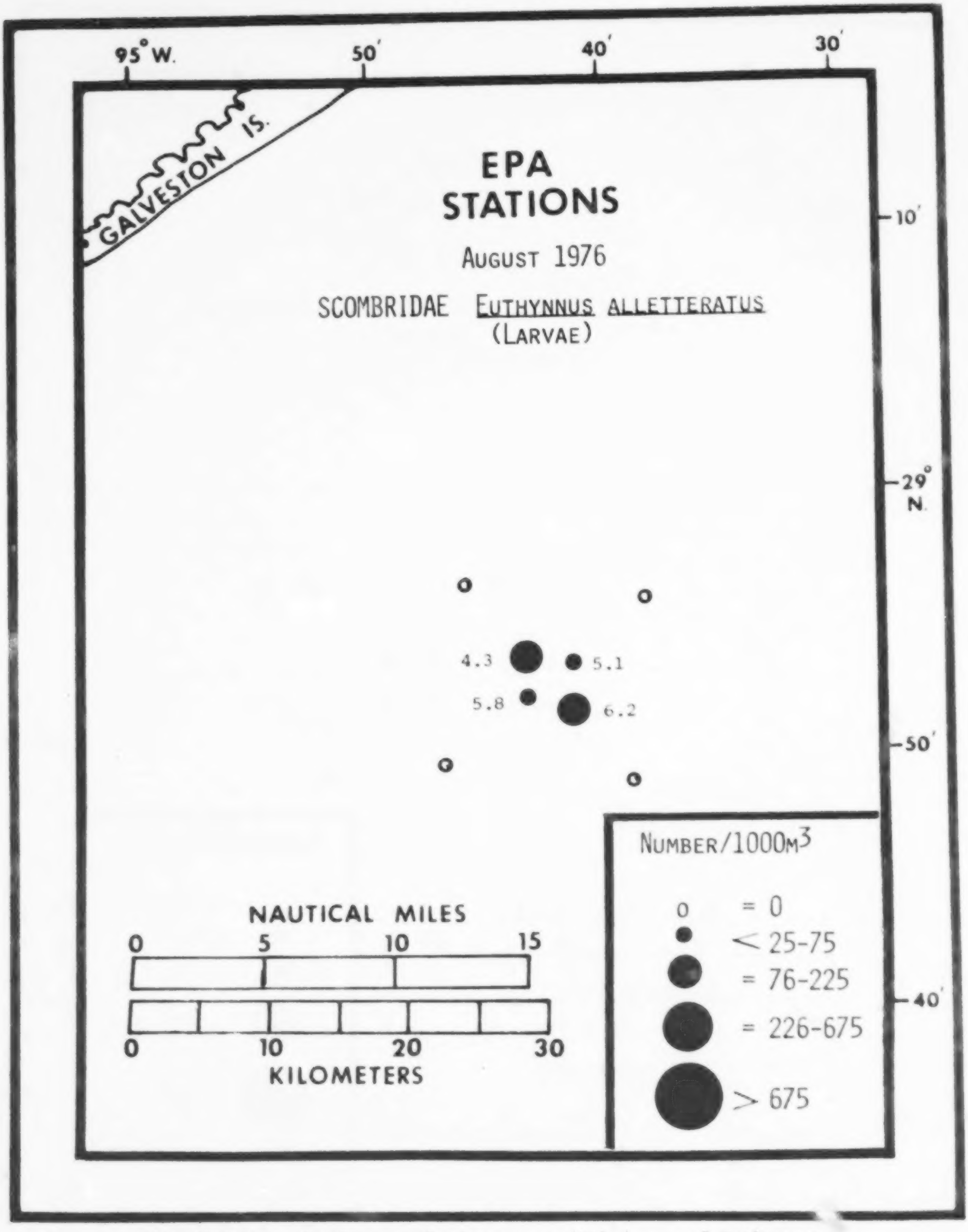

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA
STATIONS
MAY 1976
SCOMBRIDAE EUTHYNNUS ALLETTERATUS
(LARVAE)
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 39. Distribution, abundance and size range (SL) in mm of *Euthynnus alletteratus* larvae in the Buccaneer oil field area during May 1976.



95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
AUGUST 1976
SCOMBRIDAE EUTHYNNUS ALLETTERATUS (LARVAE)
4.3
5.1
5.8
6.2
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 40. Distribution, abundance and size range (SL) in mm of *Euthynnus alletteratus* larvae in the Buccaneer oil field area during August 1976.

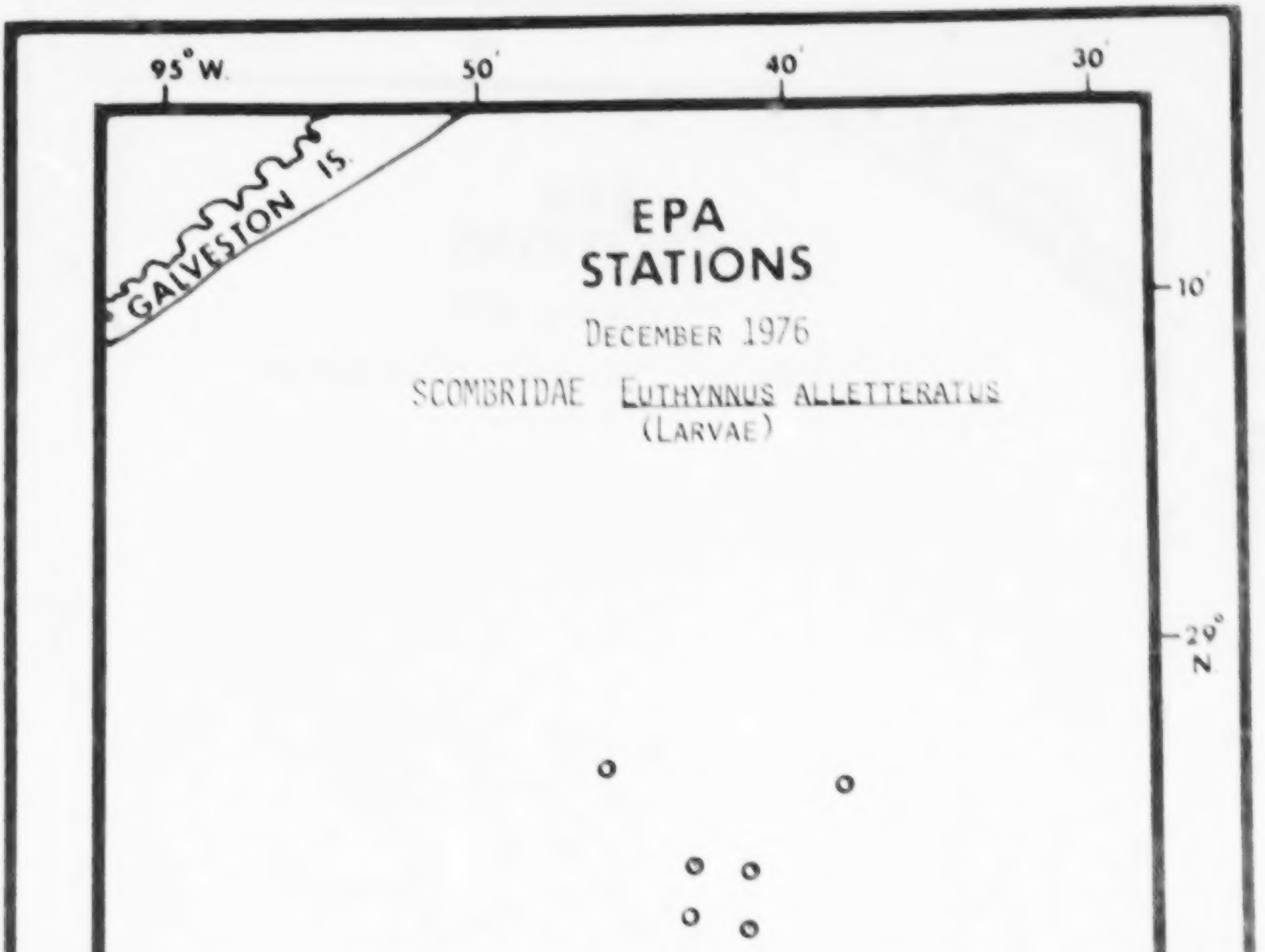

95° W.
50'
40'
30'
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
SCOMBRIDAE Euthynnus alletteratus
(LARVAE)
10'
29° N.
50'
40'
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0 5 10 15
0 10 20 30
KILOMETERS

Figure 41. Distribution, abundance and size range (SL) in mm of *Euthynnus alletteratus* larvae in the Buccaneer oil field area during December 1976.

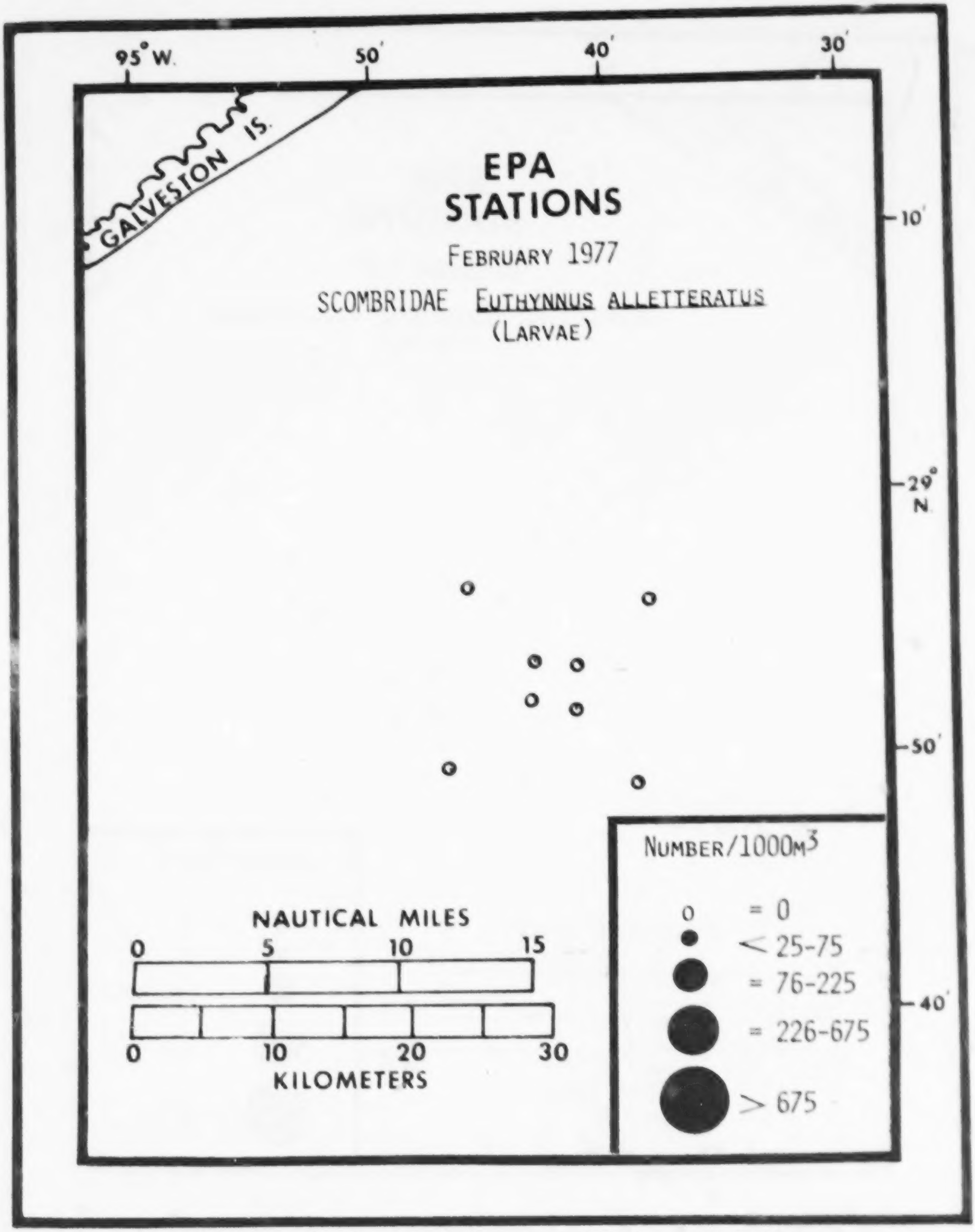

95° W.
50'
40'
30'
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
SCOMBRIDAE Euthynnus alletteratus
(LARVAE)
10'
29° N.
50'
40'
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M³
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 42. Distribution, abundance and size range (SL) in mm of Euthynnus alletteratus larvae in the Buccaneer oil field area during February 1977.

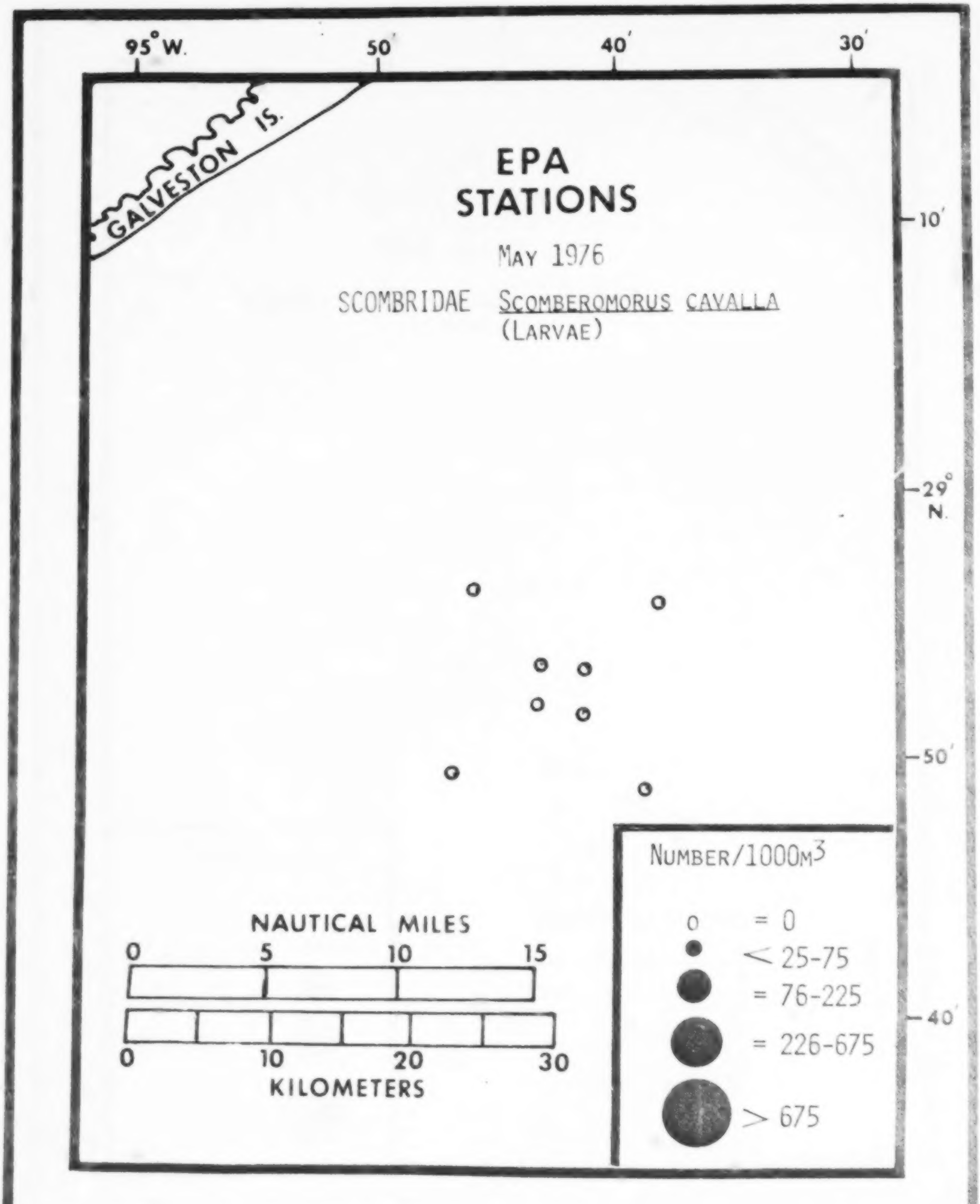

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
MAY 1976
SCOMBRIDAE Scomberomorus cavalla
(LARVAE)
NUMBER/1000M³
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 43. Distribution, abundance and size range (SL) in mm of *Scomberomorus cavalla* larvae in the Buccaneer oil field area during May 1976.

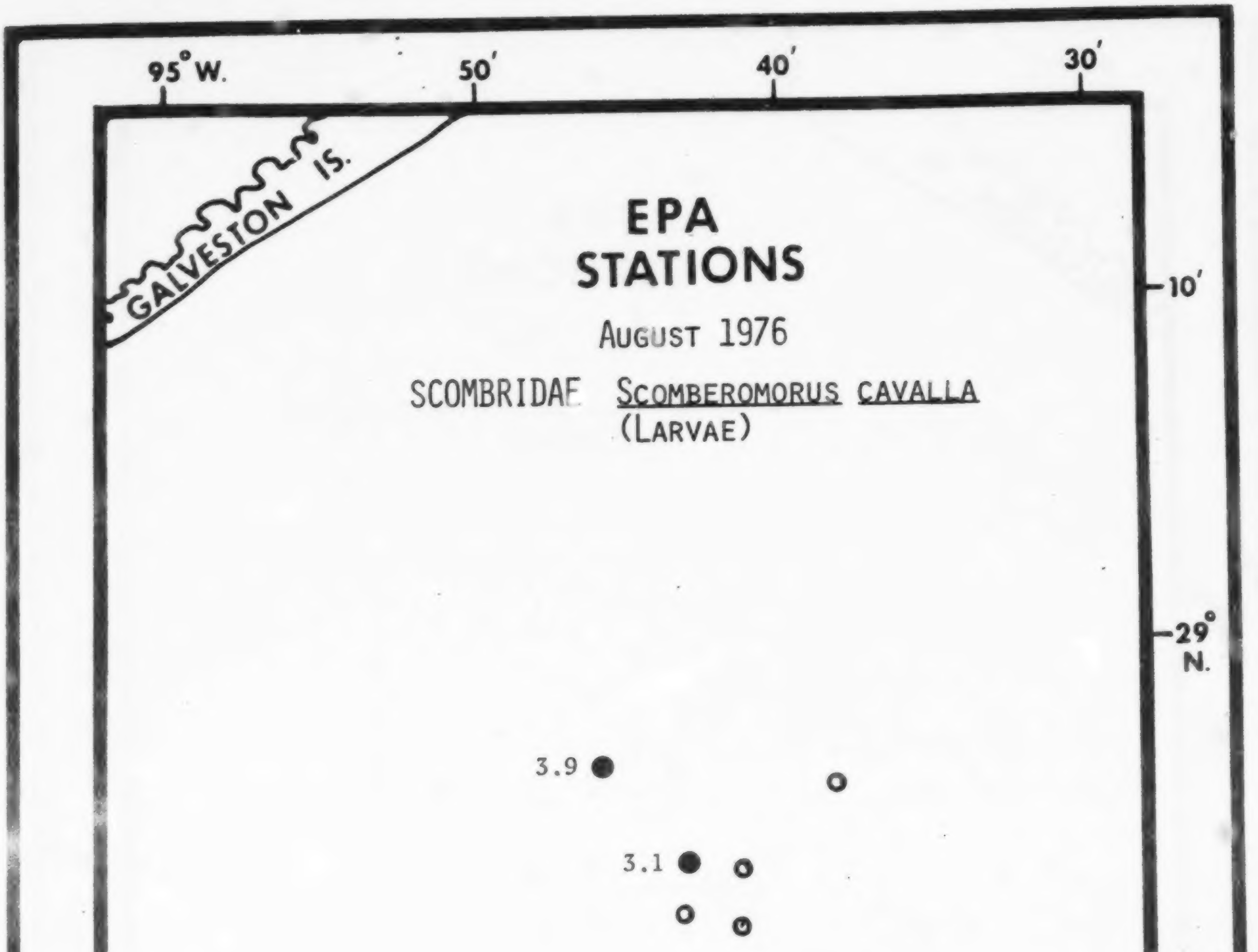

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
AUGUST 1976
SCOMBRIDAE SCOMBEROMORUS CAVALLA
(LARVAE)
10′
29° N.
50′
40′
3.9
3.1
4.3
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 44. Distribution, abundance and size range (SL) in mm of *Scomberomorus cavalla* larvae in the Buccaneer oil field area during August 1976.

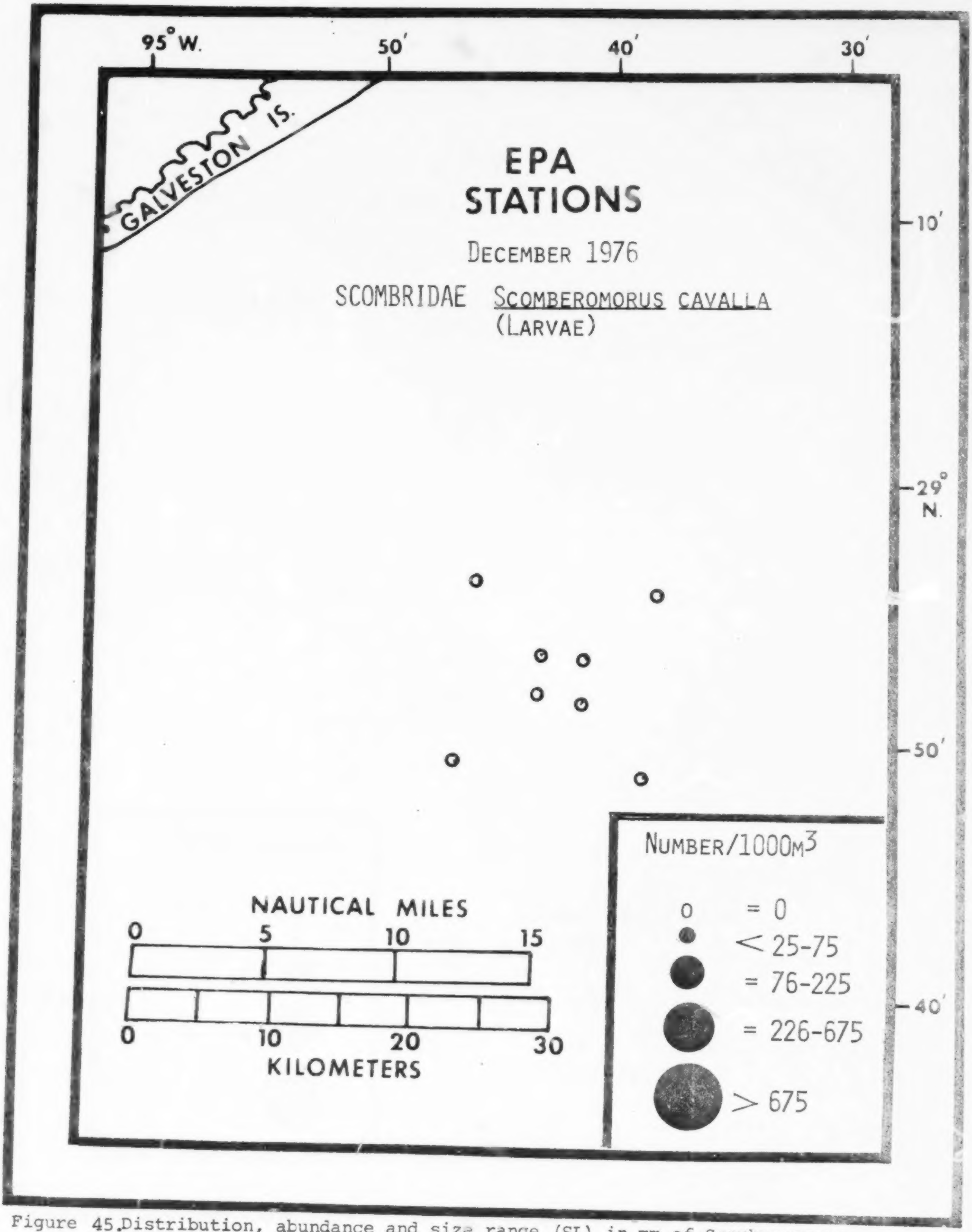

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
DECEMBER 1976
SCOMBRIDAE SCOMBEROMORUS CAVALLA
(LARVAE)
10′
29° N.
50′
40′
NAUTICAL MILES
0 5 10 15
0 10 20 30
KILOMETERS
NUMBER/1000M3
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 45. Distribution, abundance and size range (SL) in mm of *Scomberomorus cavalla* larvae in the Buccaneer oil field area during December 1976.

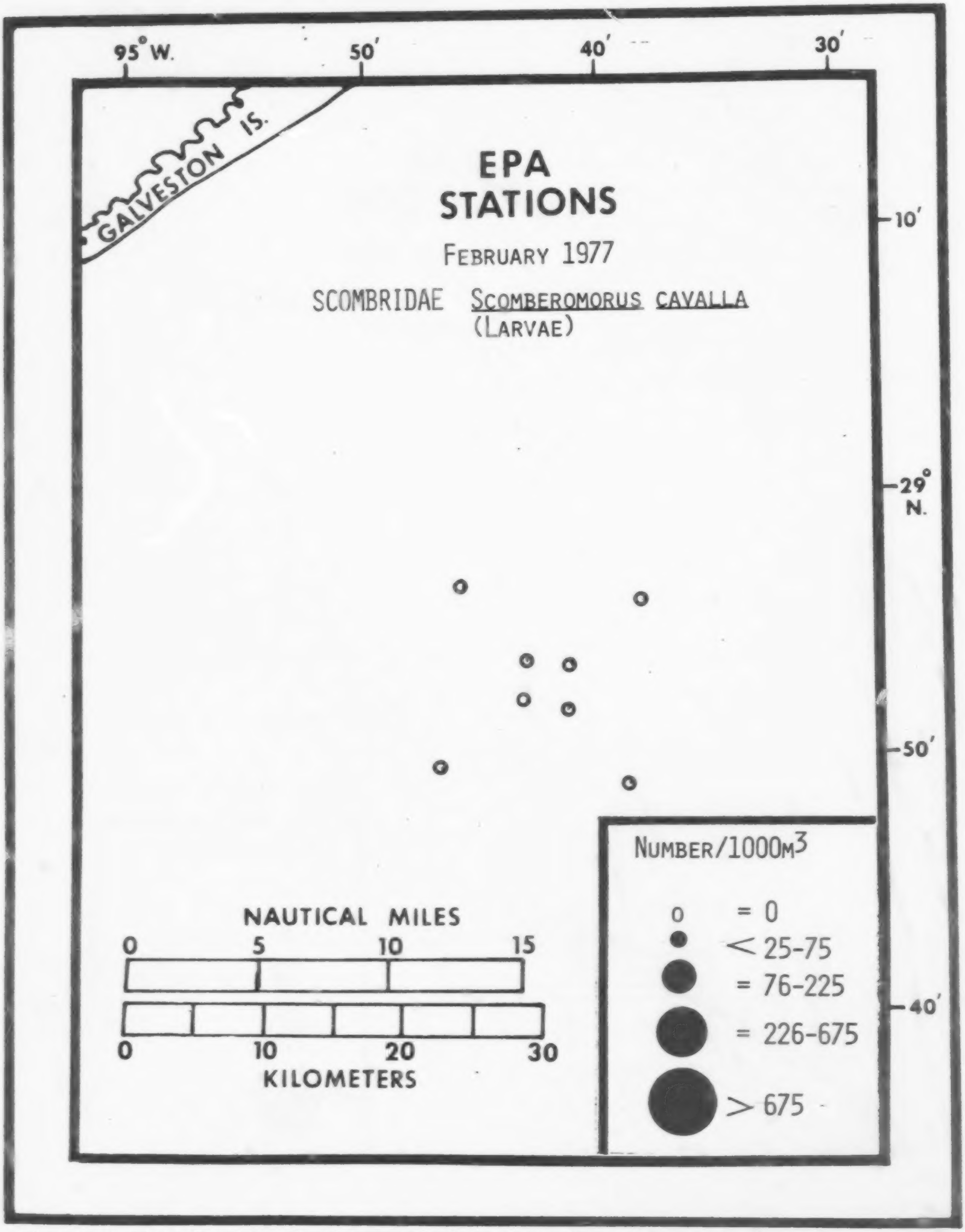

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
SCOMBRIDAE Scomberomorus cavalla
(LARVAE)
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 46. Distribution, abundance and size range (SL) in mm of Scomberomorus cavalla larvae in the Buccaneer oil field area during February 1977.

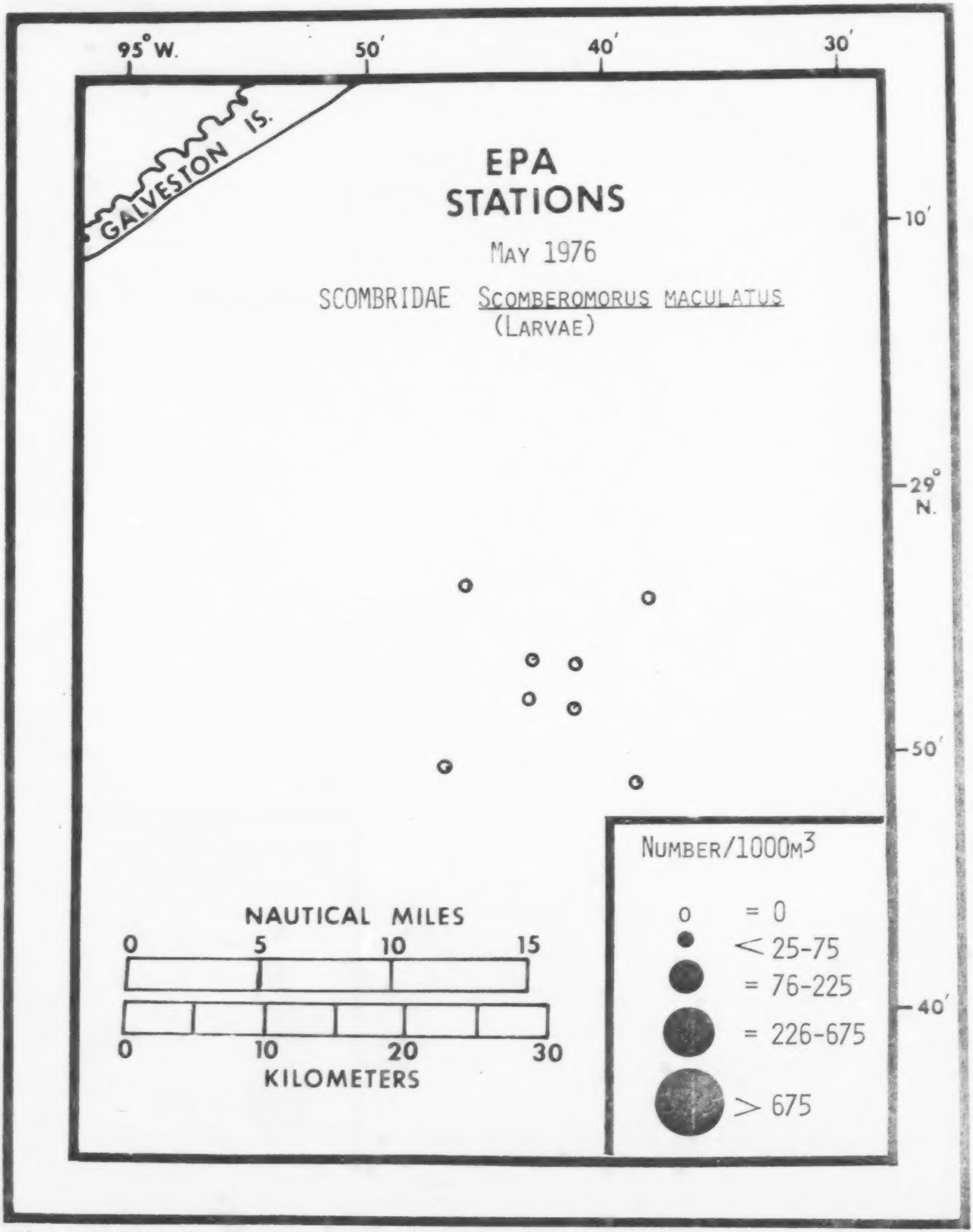

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
MAY 1976
SCOMBRIDAE Scomberomorus maculatus
(LARVAE)
NUMBER/1000M³
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0 5 10 15
0 10 20 30
KILOMETERS

Figure 47. Distribution, abundance and size range (SL) in mm of Scomberomorus maculatus larvae in the Buccaneer oil field area during May 1976.

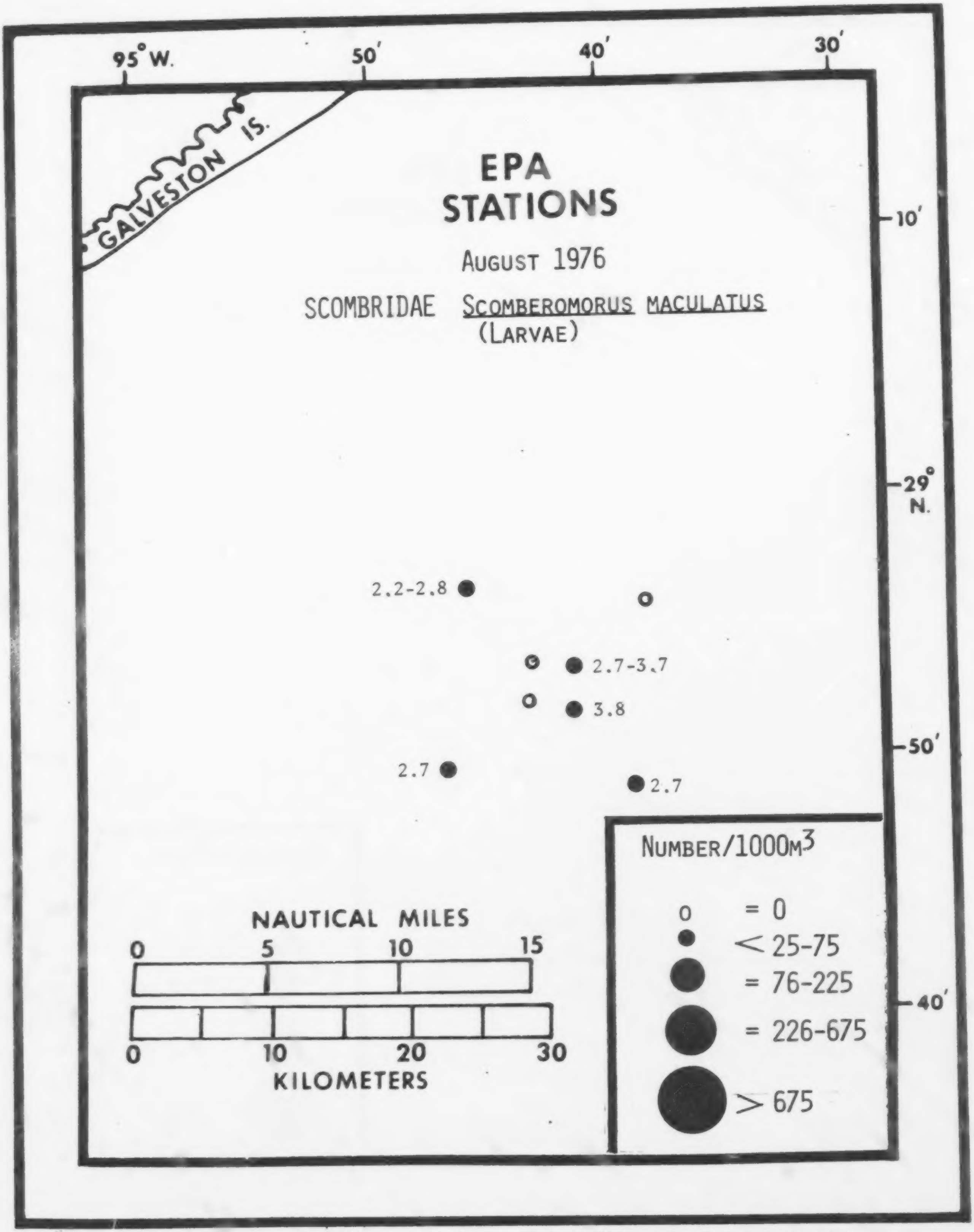

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
AUGUST 1976
SCOMBRIDAE Scomberomorus maculatus
(LARVAE)
10′
29° N.
50′
40′
2.2-2.8
2.7-3.7
3.8
2.7
2.7
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 48. Distribution, abundance and size range (SL) in mm of Scomberomorus maculatus larvae in the Buccaneer oil field area during August 1976.

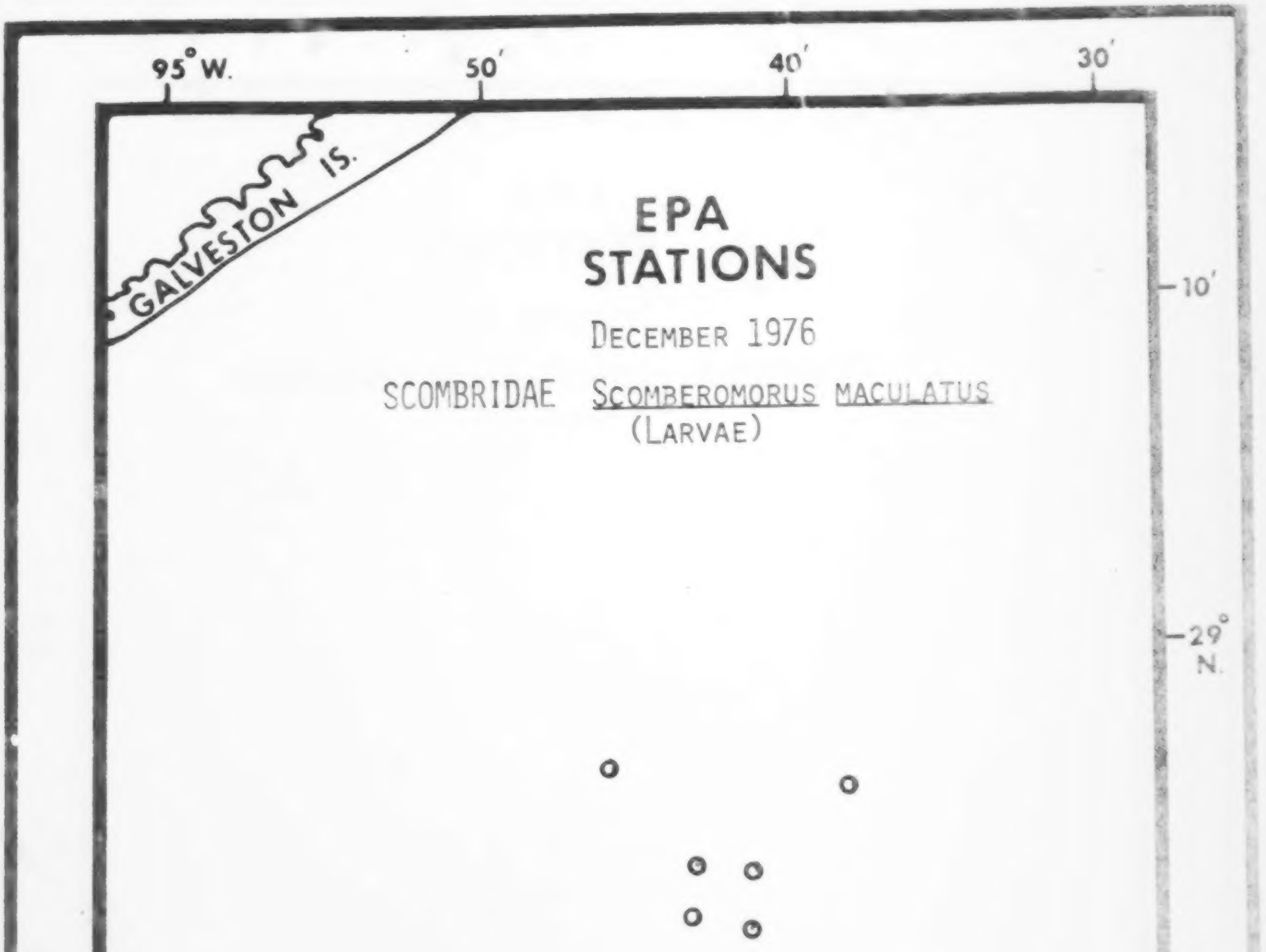

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
SCOMBRIDAE Scomberomorus maculatus (LARVAE)
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 49. Distribution, abundance and size range (SL) in mm of Scomberomorus maculatus larvae in the Buccaneer oil field area during December 1976.

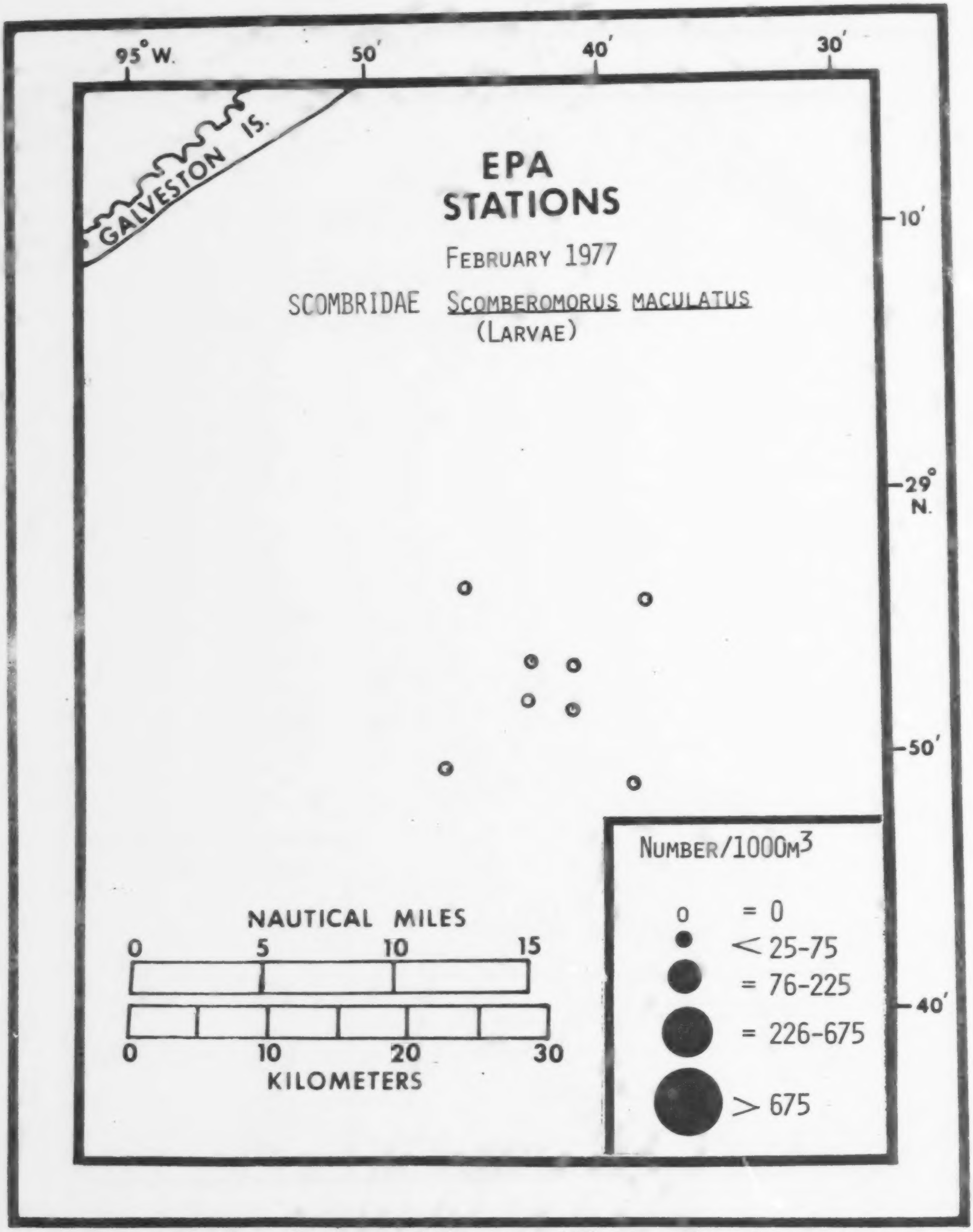

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
SCOMBRIDAE Scomberomorus maculatus
(LARVAE)
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 50. Distribution, abundance and size range (SL) in mm of *Scomberomorus maculatus* larvae in the Buccaneer oil field area during February 1977.

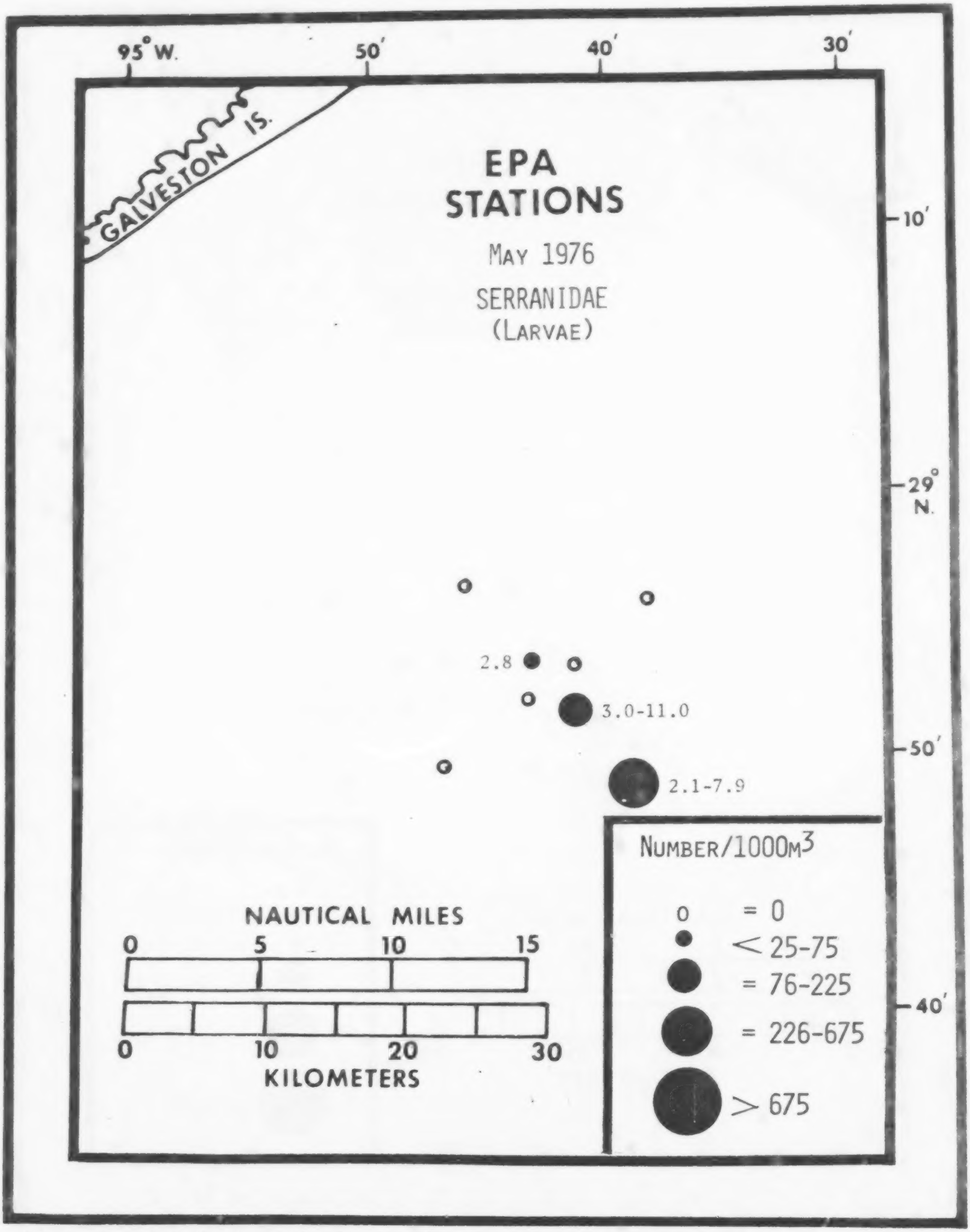

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
MAY 1976
SERRANIDAE
(LARVAE)
10′
29° N.
50′
40′
2.8
3.0-11.0
2.1-7.9
NUMBER/1000M3
o = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 51.Distribution, abundance and size range (SL) in mm of serranid larvae in the Buccaneer oil field area during May 1976.

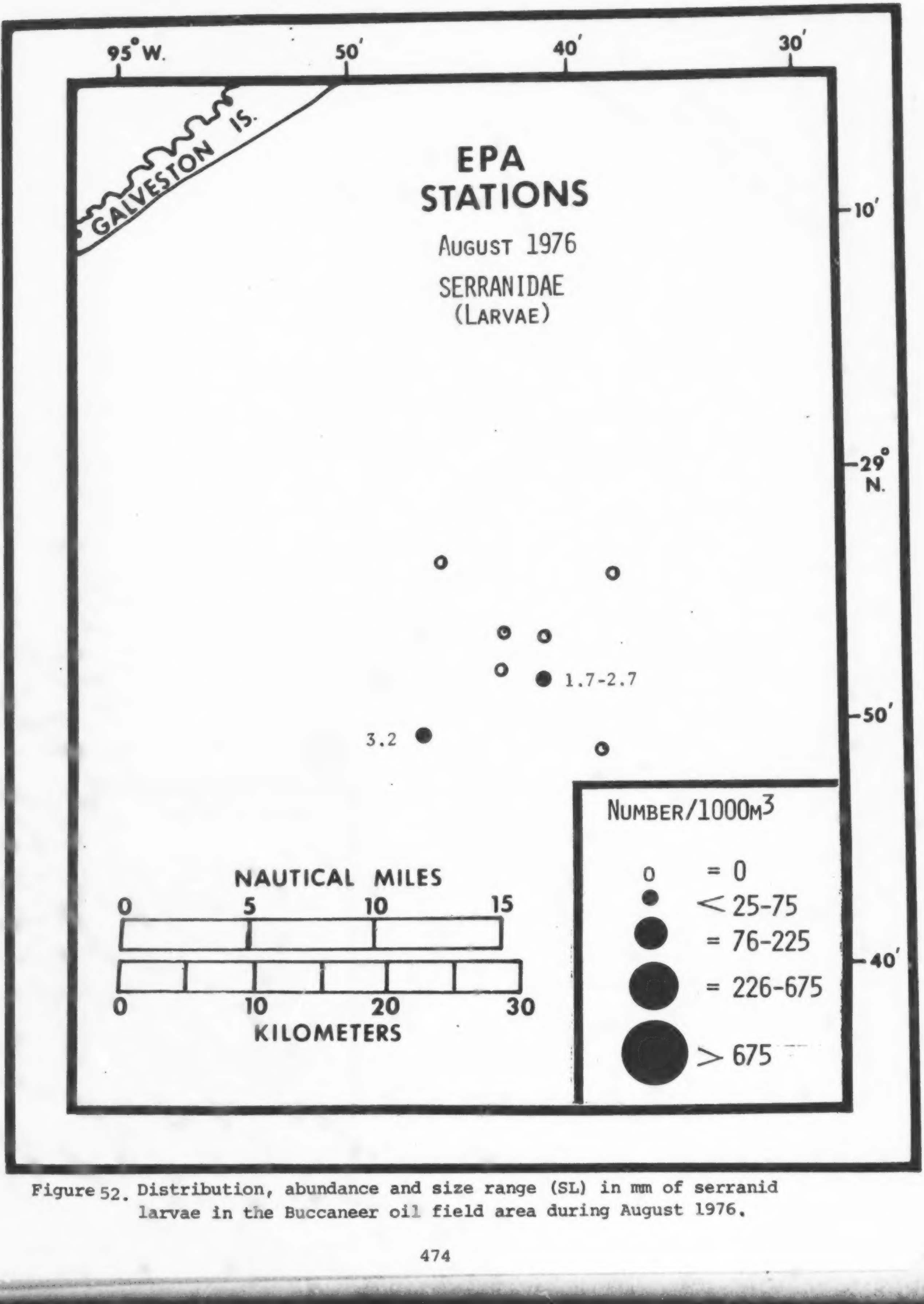

95° W.
50'
40'
30'
GALVESTON IS.
EPA
STATIONS
AUGUST 1976
SERRANIDAE
(LARVAE)
10'
29° N.
50'
40'
1.7-2.7
3.2
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
< 25-75
= 76-225
= 226-675
> 675

Figure 52. Distribution, abundance and size range (SL) in mm of serranid larvae in the Buccaneer oil field area during August 1976.

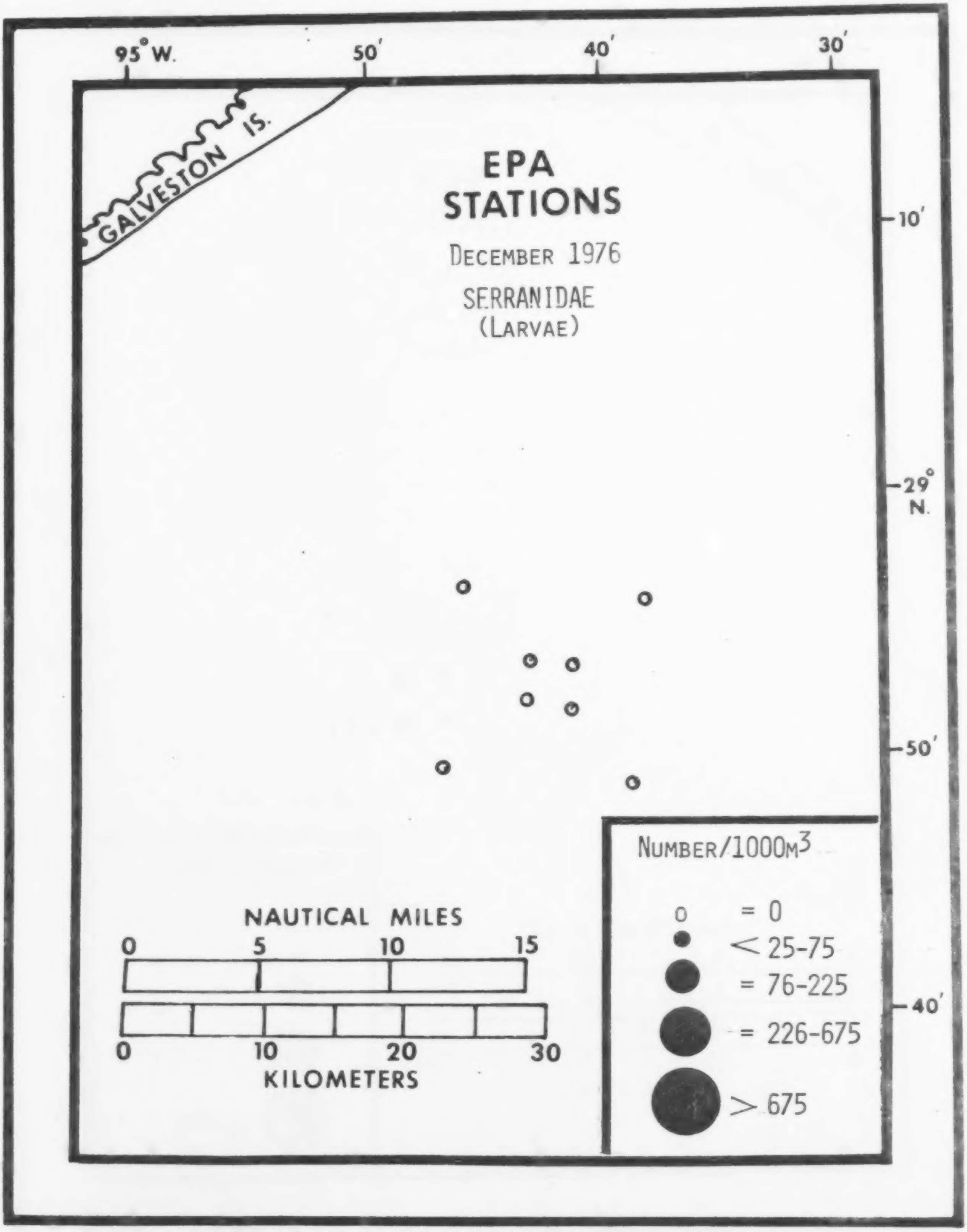

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
DECEMBER 1976
SERRANIDAE
(LARVAE)
10′
29°
N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000m³
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675

Figure 53.Distribution, abundance and size range (SL) in mm of serranid larvae in the Buccaneer oil field area during December 1976.

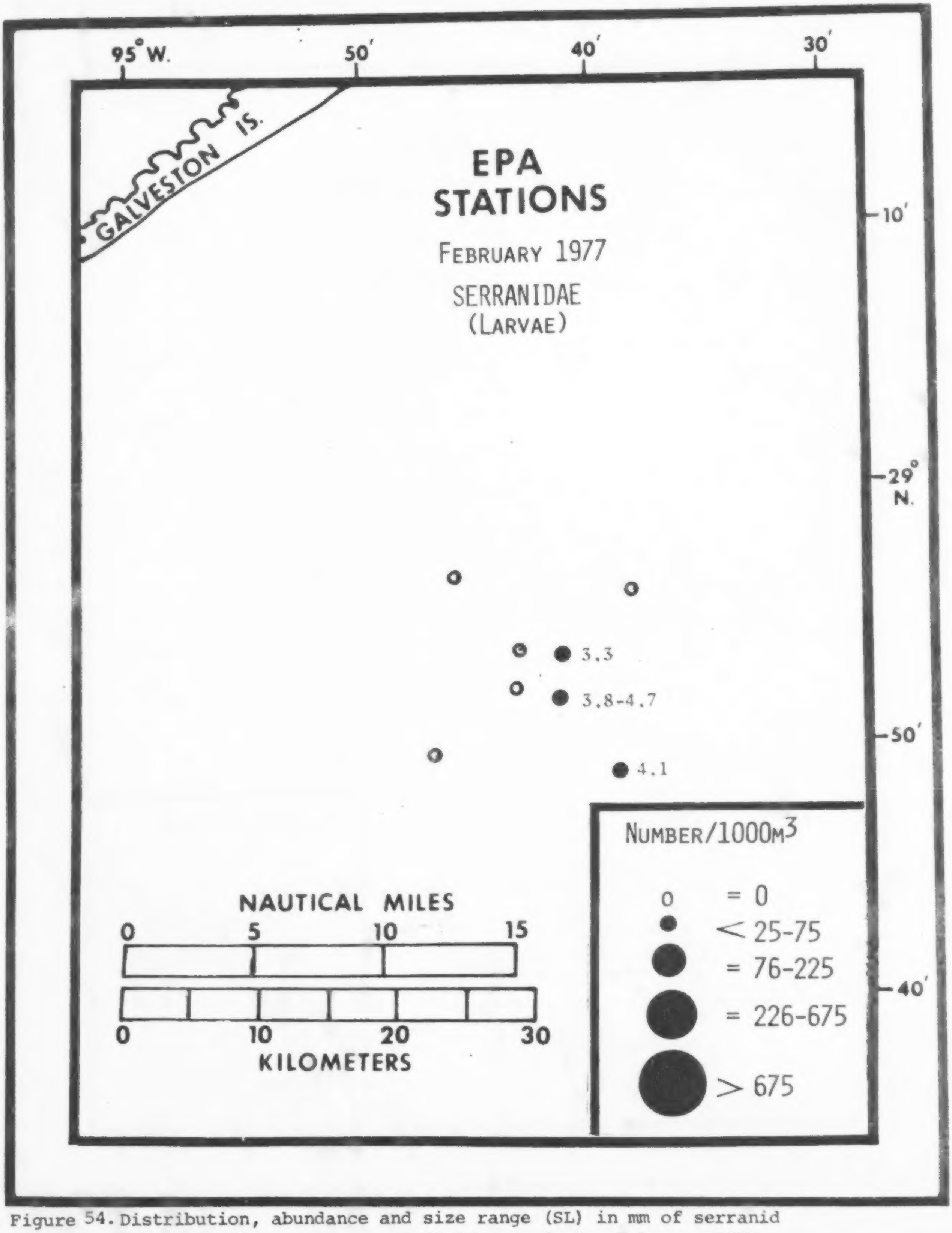

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
FEBRUARY 1977
SERRANIDAE
(LARVAE)
10′
29°
N.
50′
40′
3.3
3.8-4.7
4.1
NUMBER/1000M3
○ = 0
● < 25-75
● = 76-225
● = 226-675
● > 675
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 54. Distribution, abundance and size range (SL) in mm of serranid larvae in the Buccaneer oil field area during February 1977.

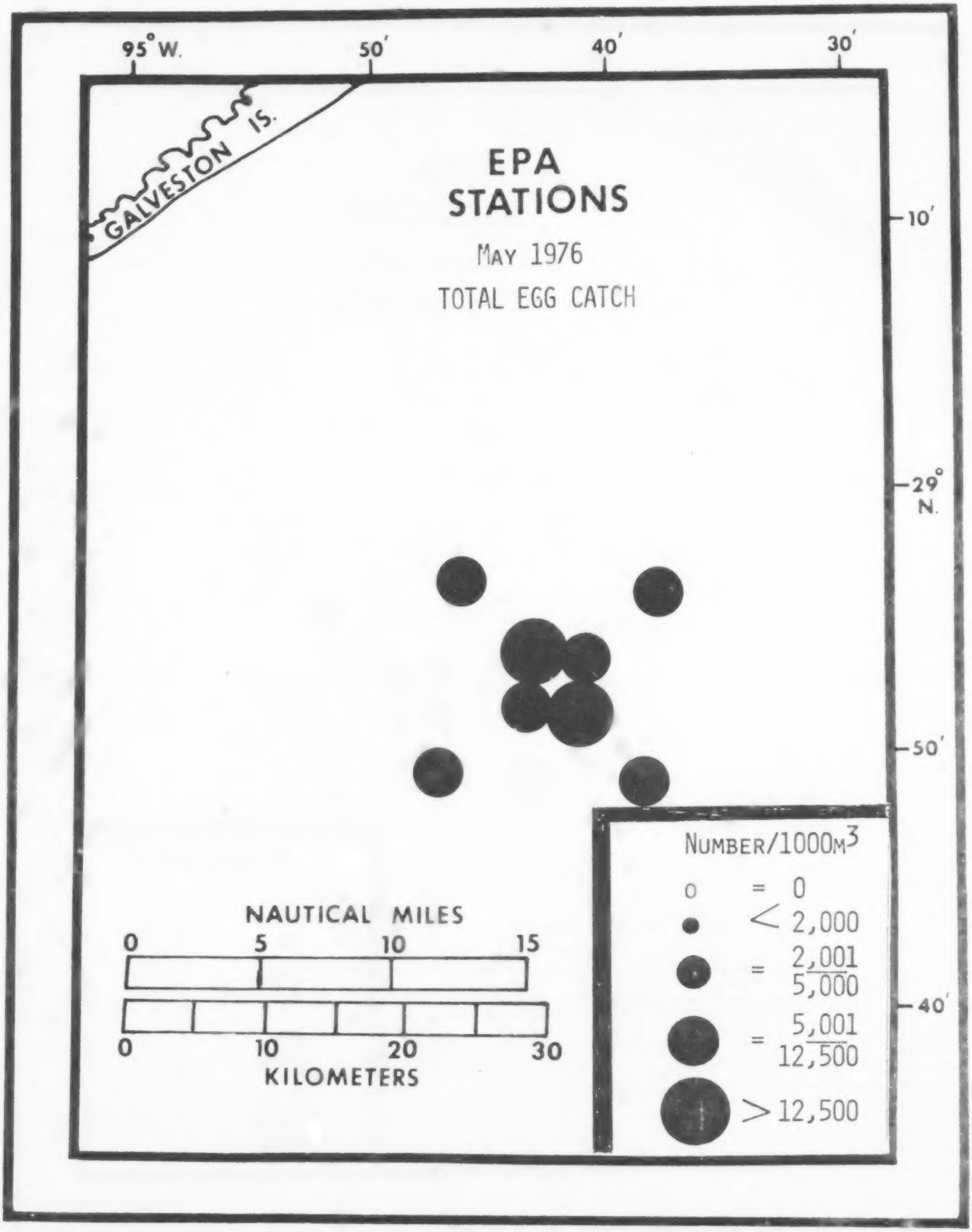

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
MAY 1976
TOTAL EGG CATCH
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M^3
o = 0
< 2,000
= 2,001 / 5,000
= 5,001 / 12,500
> 12,500

Figure 55. Distribution and abundance of fish eggs in the Buccaneer oil field area during May 1976.

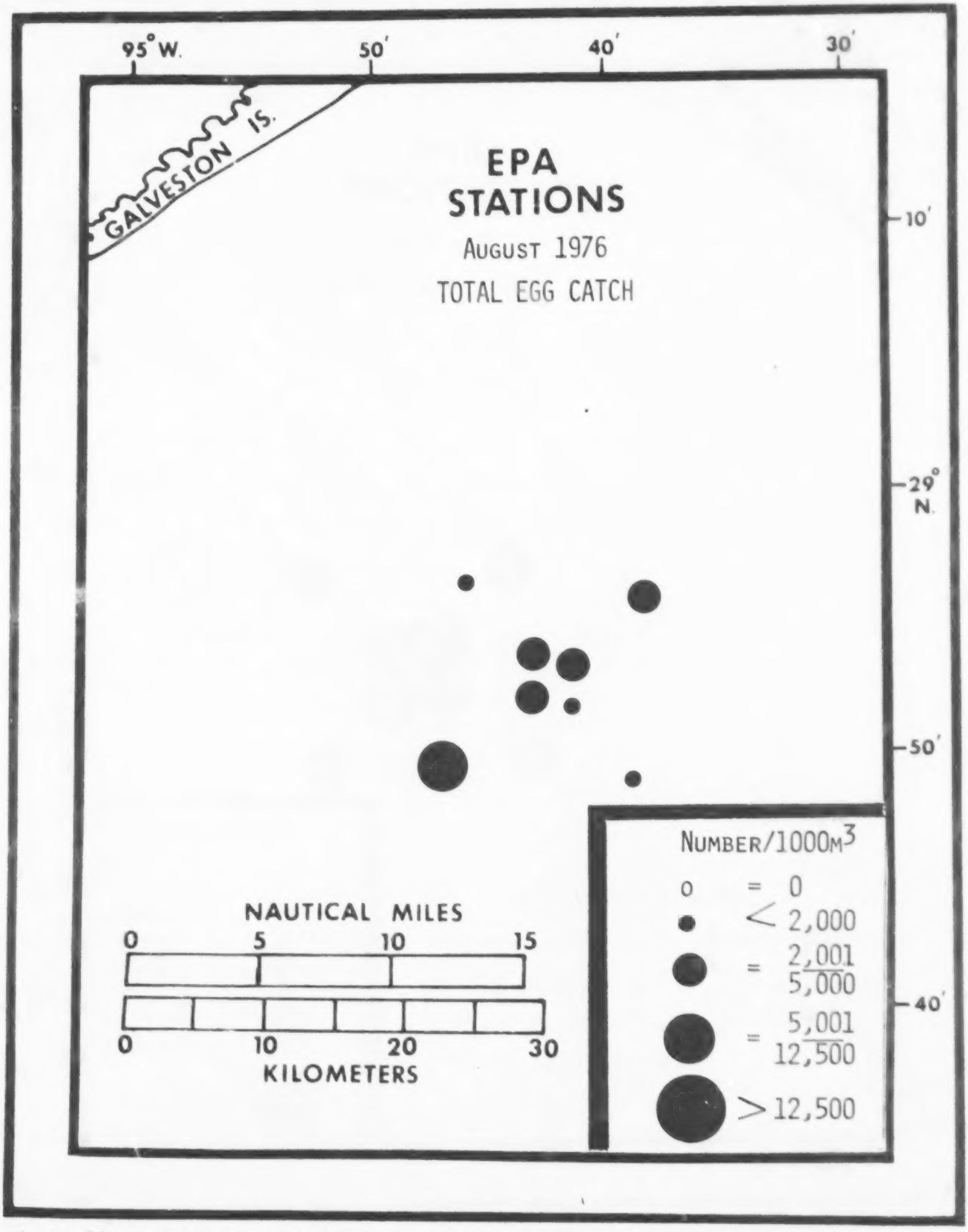

95°W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
AUGUST 1976
TOTAL EGG CATCH
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 2,000
● = 2,001 5,000
● = 5,001 12,500
● > 12,500

Figure 56. Distribution and abundance of fish eggs in the Buccaneer oil field area during August 1976.

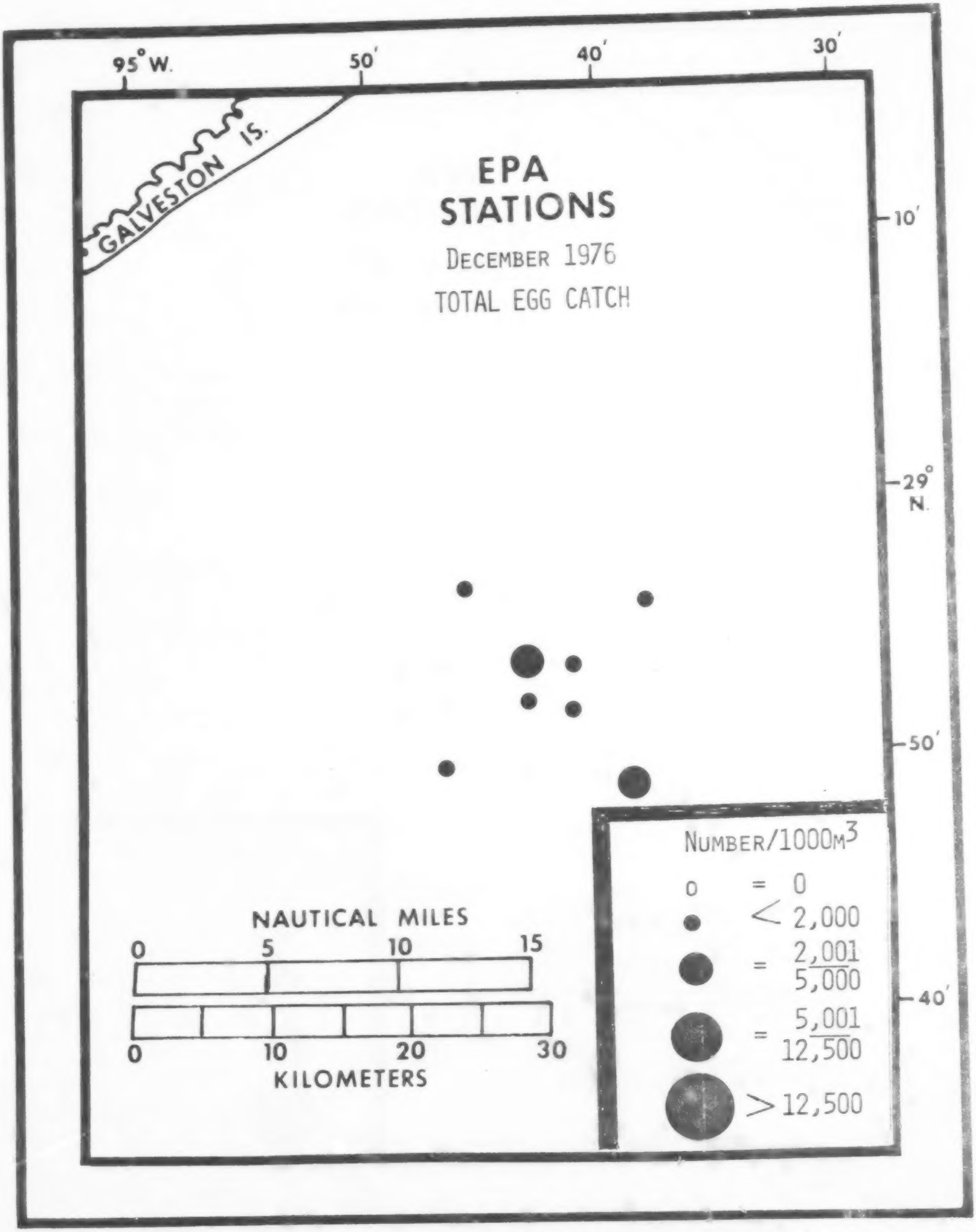

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
TOTAL EGG CATCH
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 2,000
● = 2,001 5,000
● = 5,001 12,500
● > 12,500

Figure 57. Distribution and abundance of fish eggs in the Buccaneer oil field area during December 1976.

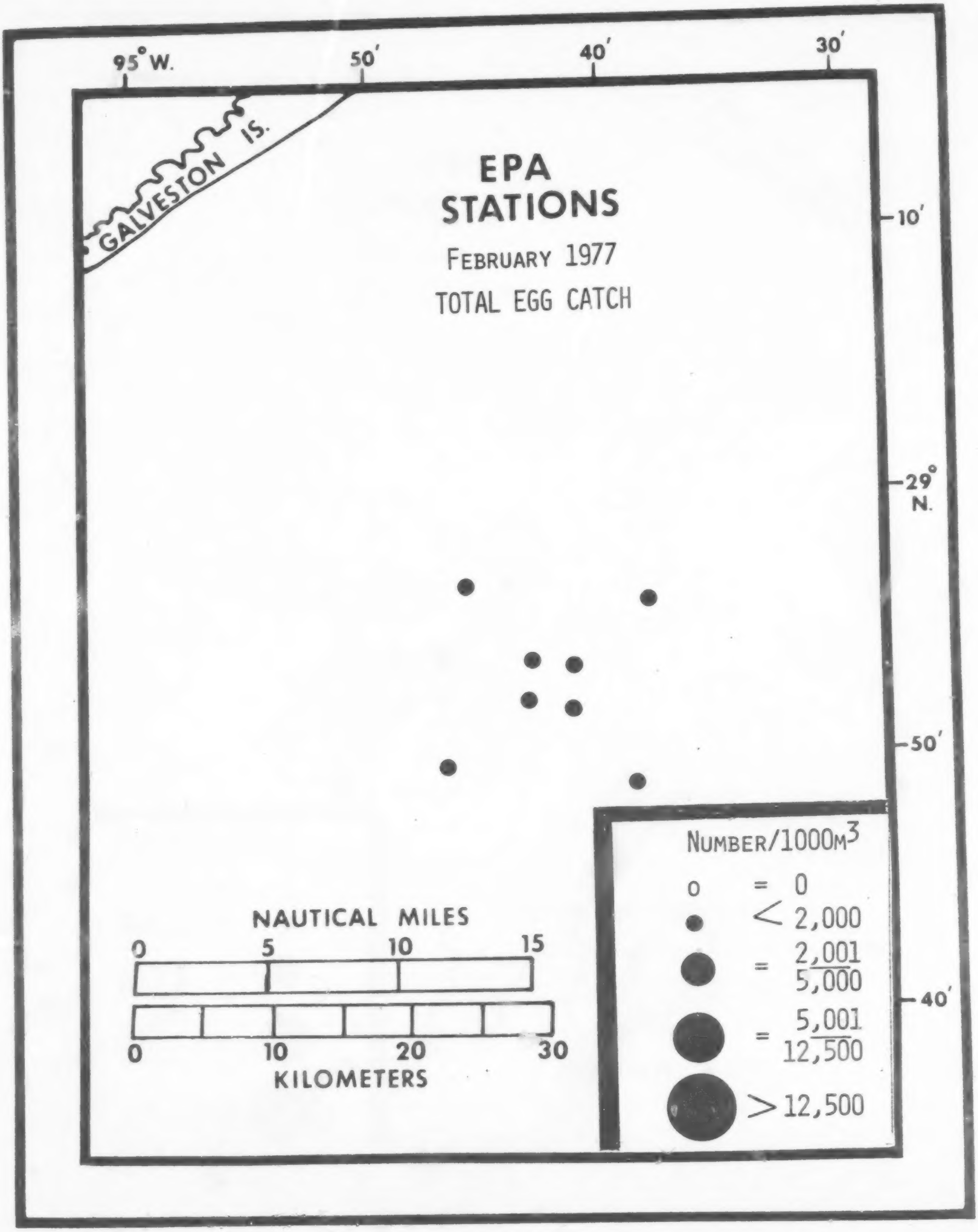

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
FEBRUARY 1977
TOTAL EGG CATCH
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M³
= 0
< 2,000
= 2,001 / 5,000
= 5,001 / 12,500
> 12,500

Figure 58. Distribution and abundance of fish eggs in the Buccaneer oil field area during February 1977.

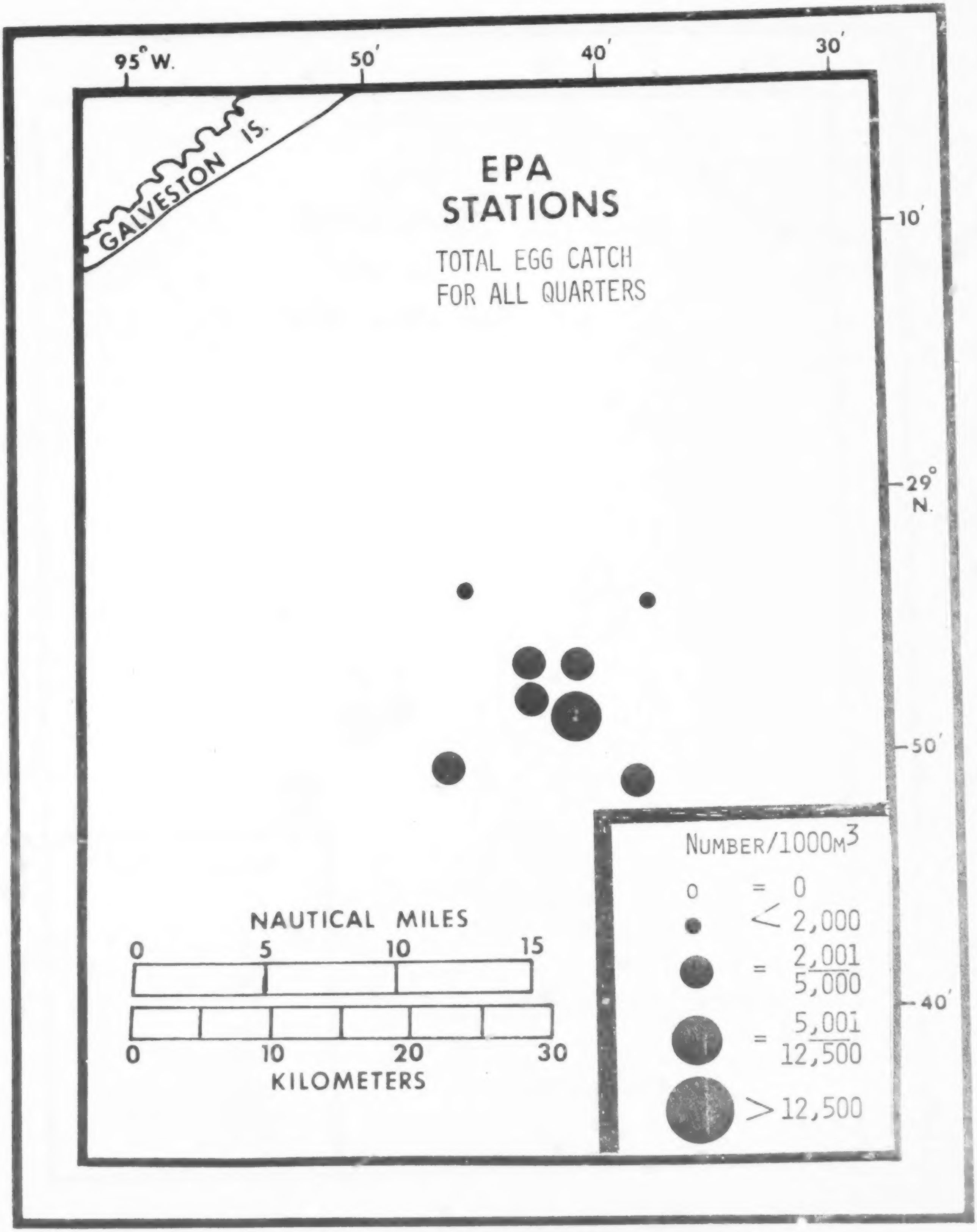

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
TOTAL EGG CATCH FOR ALL QUARTERS
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 2,000
● = 2,001/5,000
● = 5,001/12,500
● > 12,500

Figure 59. Distribution and abundance of fish eggs in the Buccaneer oil field area from May 1976 to February 1977.

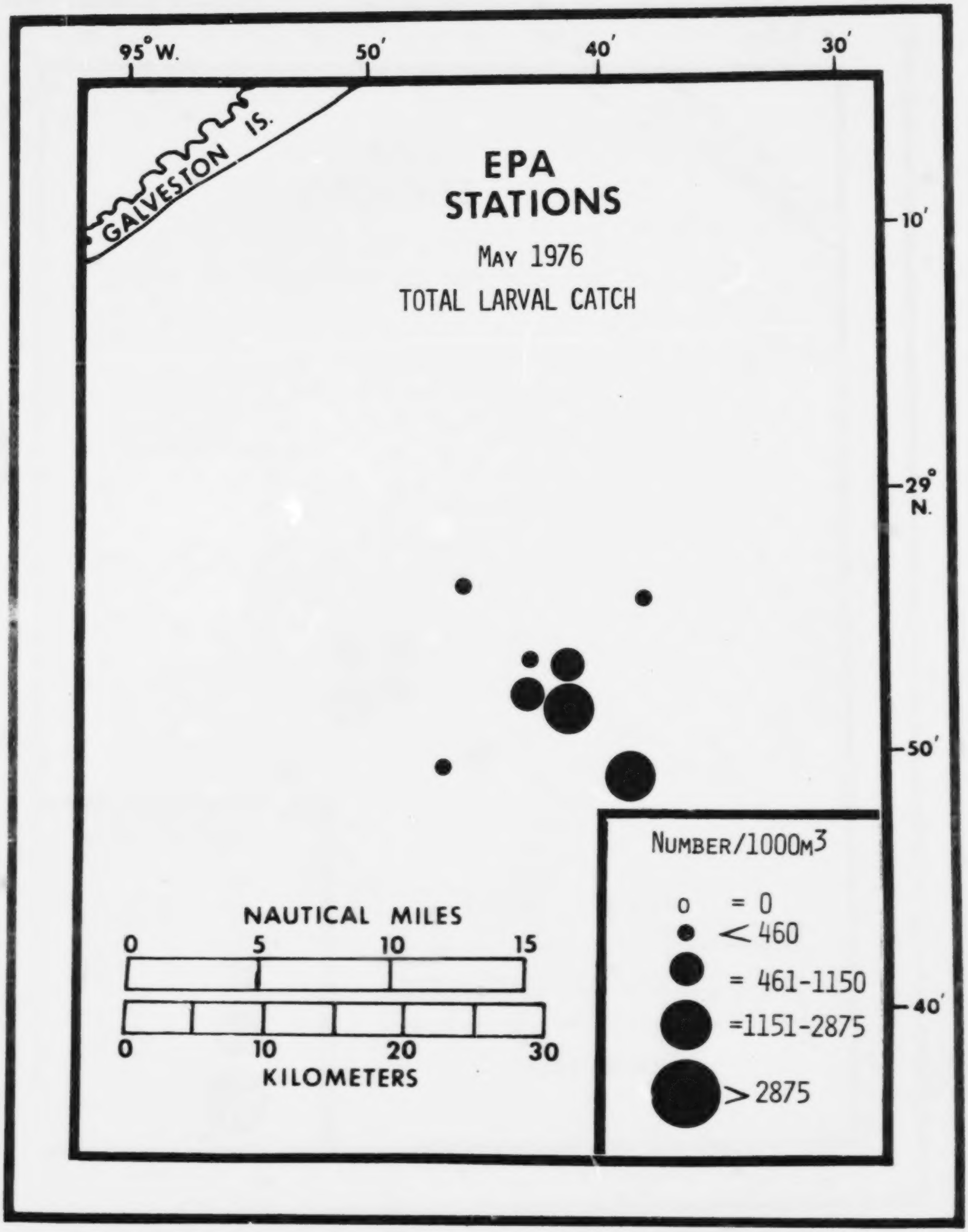

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
MAY 1976
TOTAL LARVAL CATCH
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 460
● = 461-1150
● =1151-2875
● > 2875

Figure 60. Distribution and abundance of fish larvae in the Buccaneer oil field area during May 1976.

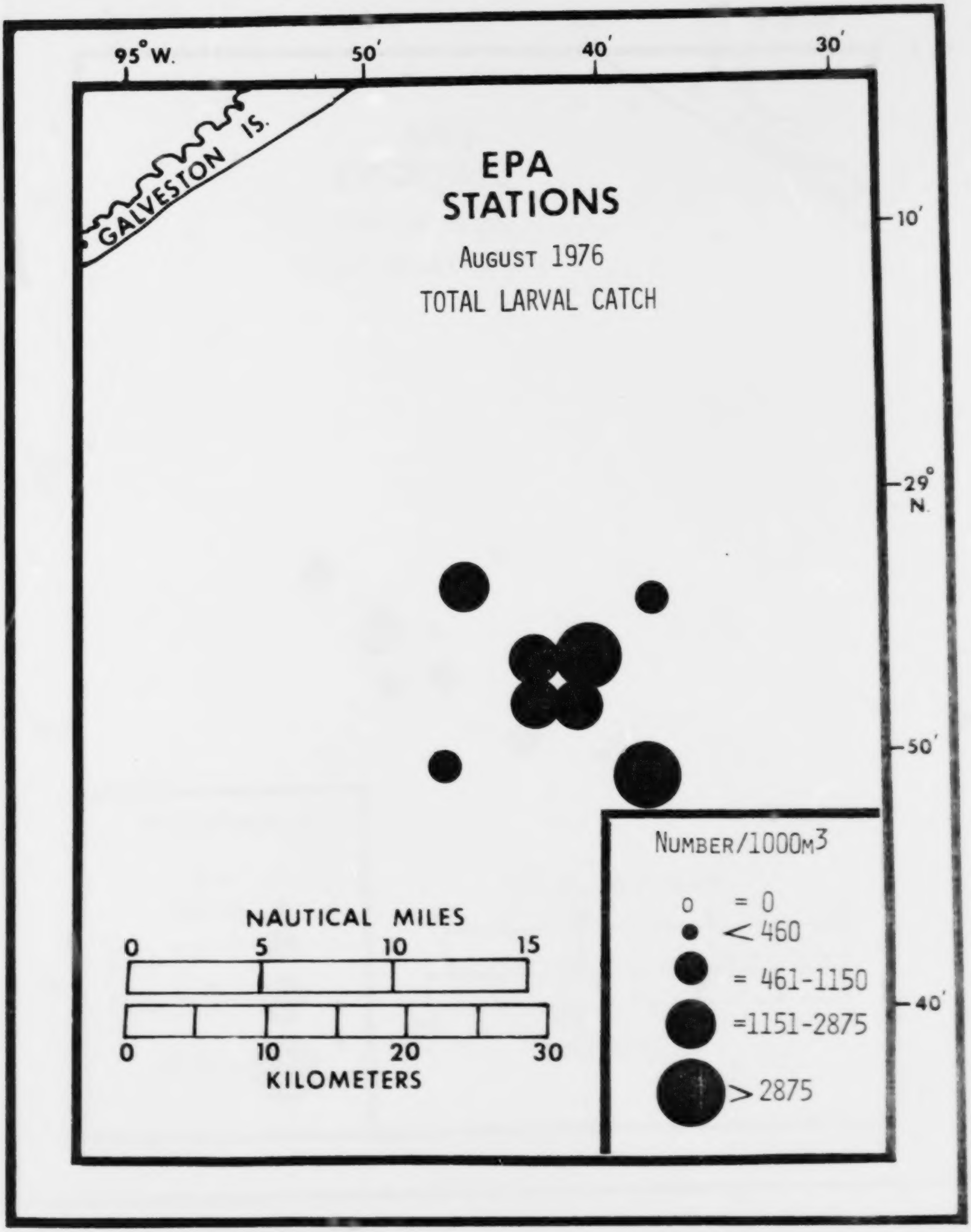

95° W.
50′
40′
30′
GALVESTON IS.
EPA
STATIONS
AUGUST 1976
TOTAL LARVAL CATCH
10′
29° N.
50′
40′
NUMBER/1000M3
o = 0
● < 460
● = 461-1150
● =1151-2875
● > 2875
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS

Figure 61. Distribution and abundance of fish larvae in the Buccaneer oil field area during August 1976.

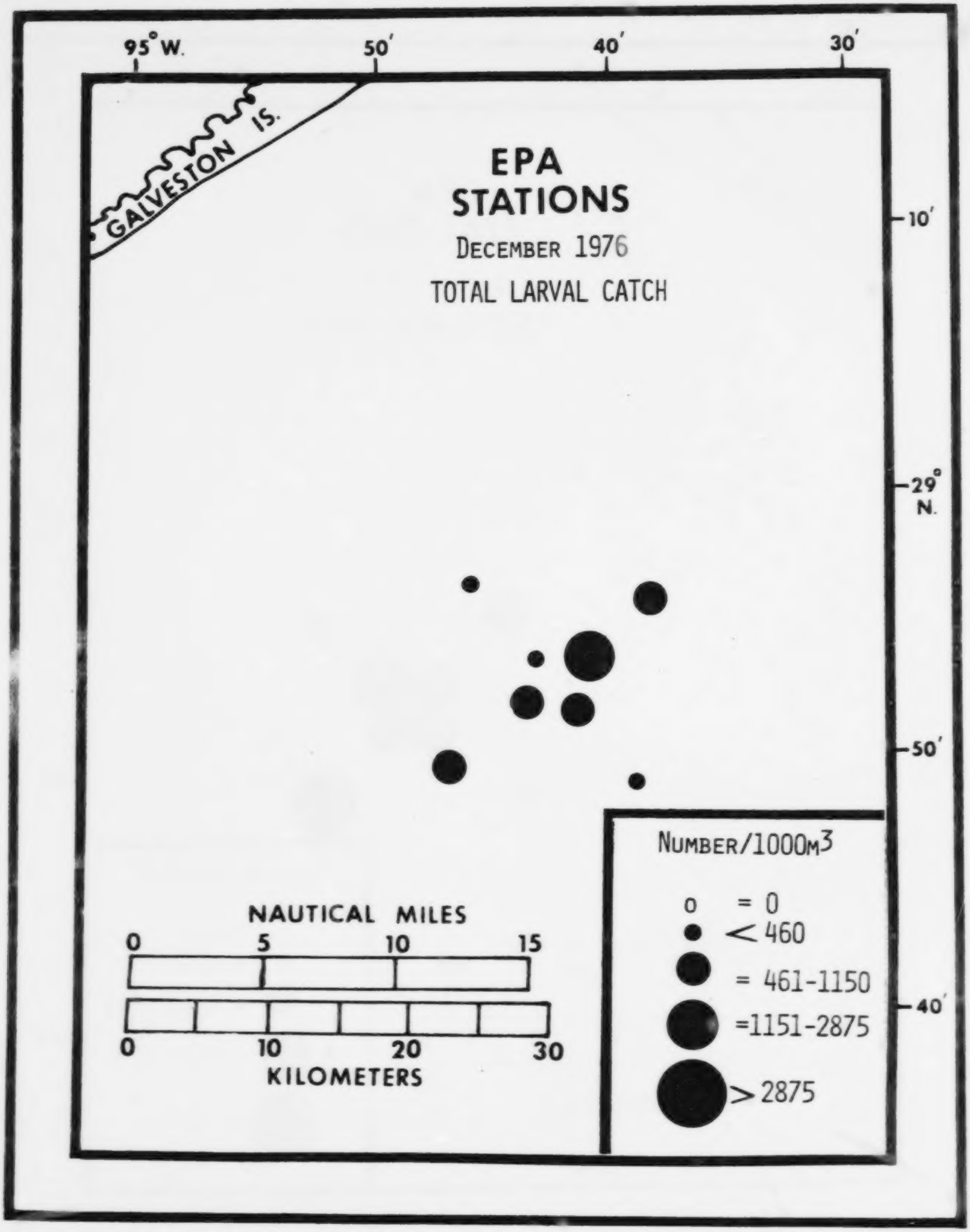
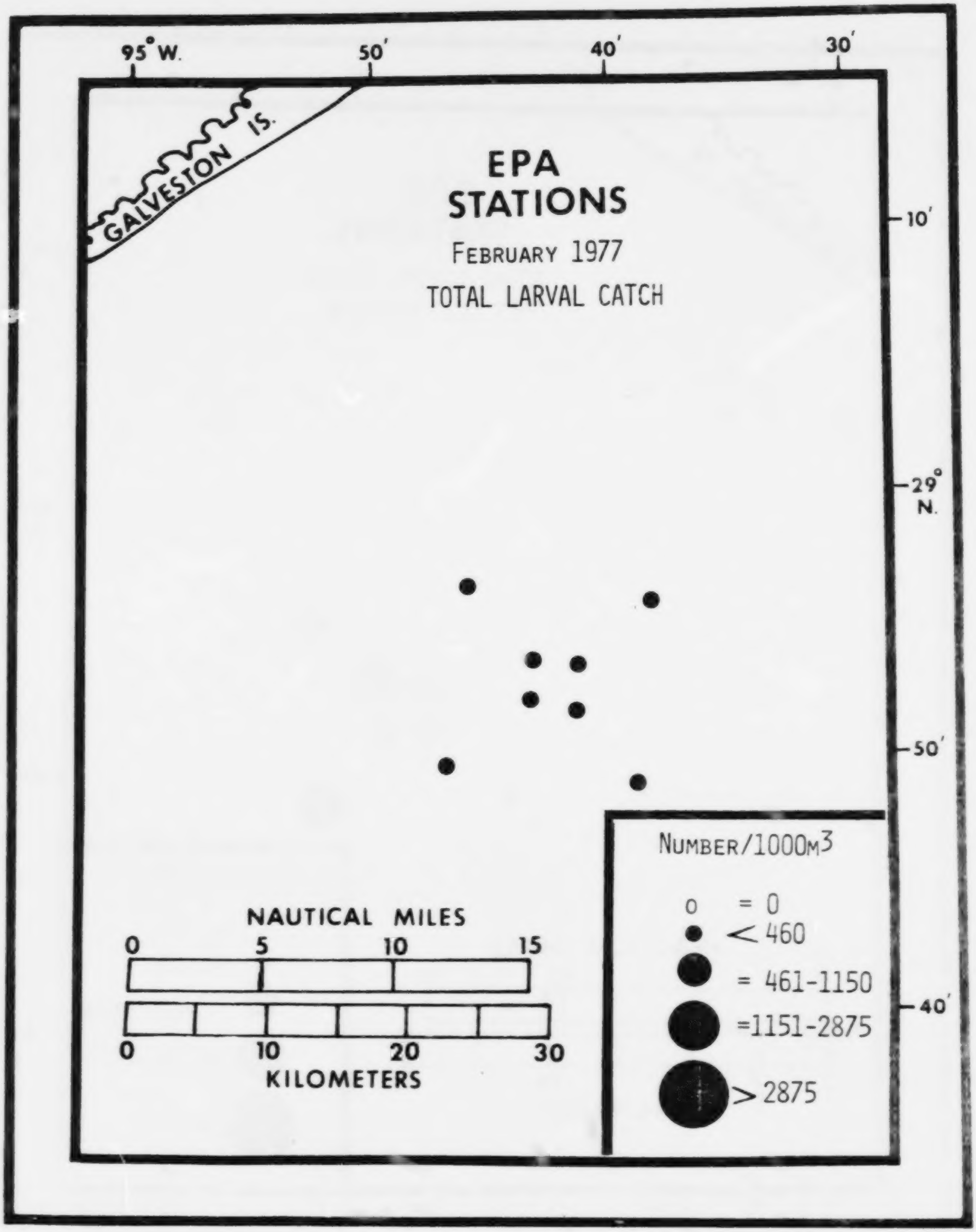

95° W.
50′
40′
30′
10′
29° N.
50′
40′
GALVESTON IS.
EPA STATIONS
DECEMBER 1976
TOTAL LARVAL CATCH
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
= 0
< 460
= 461-1150
=1151-2875
> 2875

Figure 62. Distribution and abundance of fish larvae in the Buccaneer oil field area during December 1976.



95°W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
FEBRUARY 1977
TOTAL LARVAL CATCH
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
○ = 0
● < 460
● = 461-1150
● =1151-2875
● > 2875

Figure 63. Distribution and abundance of fish larvae in the Buccaneer oil field area during February 1977.

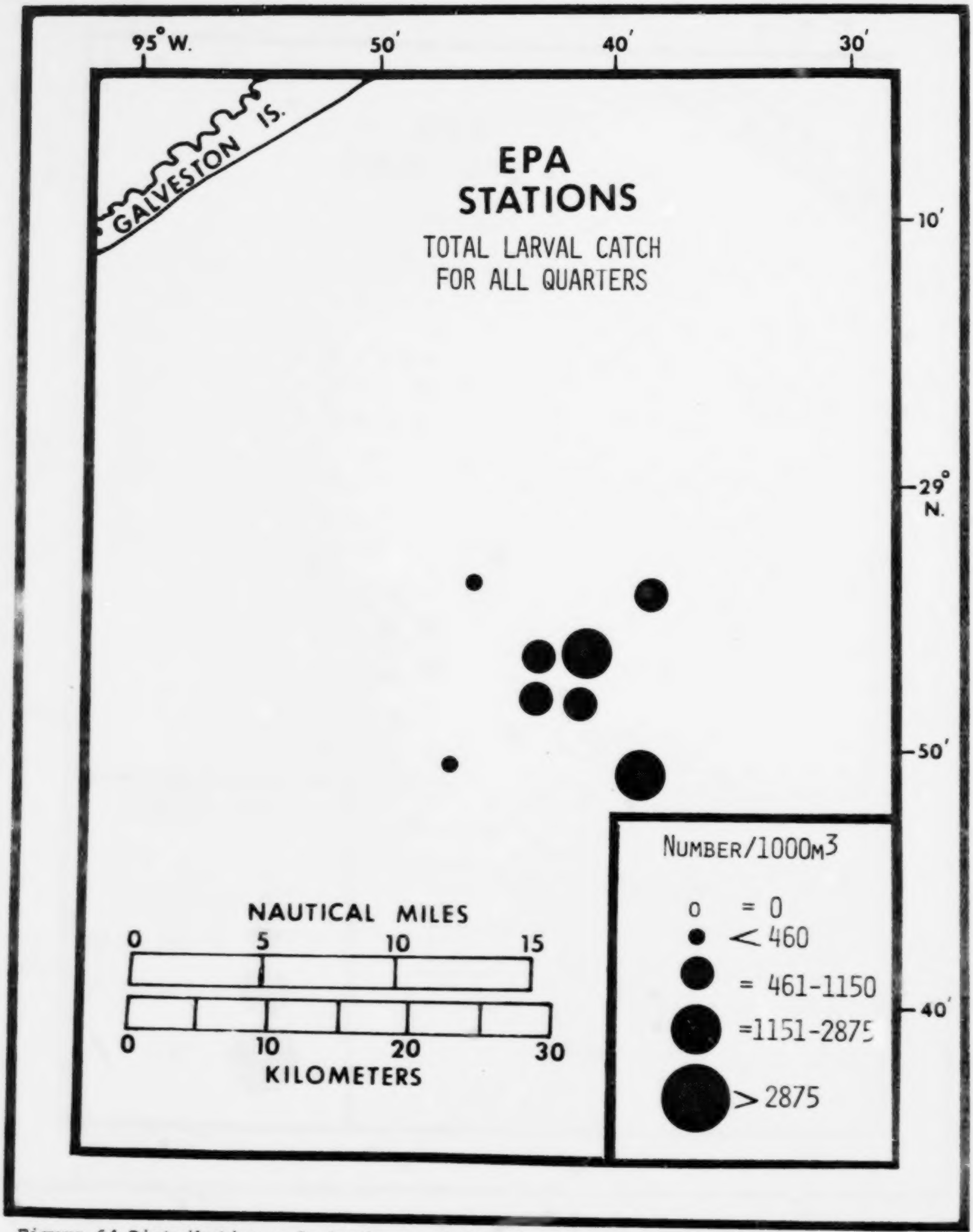

95° W.
50′
40′
30′
GALVESTON IS.
EPA STATIONS
TOTAL LARVAL CATCH FOR ALL QUARTERS
10′
29° N.
50′
40′
NAUTICAL MILES
0
5
10
15
0
10
20
30
KILOMETERS
NUMBER/1000M3
o = 0
● < 460
● = 461-1150
● =1151-2875
● > 2875

Figure 64. Distribution and abundance of fish larvae in the Buccaneer oil field area from May 1976 to February 1977.

EFFECTS OF OFFSHORE OIL FIELD STRUCTURES ON THEIR BIOTIC ENVIRONMENT: BENTHOS AND PLANKTON

Principal Investigator

Nick Fotheringham

Results presented in this report for work accomplished under Work Unit 2.3.8 entitled Effects of Offshore Oil Field Structures on Their Biotic Environment: Benthos and Plankton are tentative and are included herein only in draft form. Final corrections and additional analysis are underway. A final report for this work unit will be printed upon receipt as an addendum. The draft final report is presented herein to prevent further delay in printing and distribution of the 1976-1977 Annual Report on the Buccaneer Oil Field Study

EXECUTIVE SUMMARY

The fouling community, its planktonic larvae and its predators were studied at Buccaneer Field from May, 1976 to April, 1977. Sixteen algae and 101 invertebrates were identified from the structures. The existing fouling community was dominated by the large barnacle ***Balanus tintinnabulum***, which provided a matrix of crevices in which other invertebrates were found. Unoccupied space was rare in the natural community but persisted for several months in disturbed quadrats, especially in winter. The erect bryozoan ***Savignyella lafonti*** and the urchin ***Arbacia punctulata*** were seasonally common on the well jacket but absent or rare on the production platform. On the other hand, the erect bryozoans ***Bugula neritina*** and ***Bugula rylandi*** and the hydroid ***Tubularia crocea*** were seasonally common on the platform but rare on the well jacket. Predator exclusion cages on experimental quadrats seemed to encourage the development of ***Savignyella lafonti*** and tubes of the corophiid amphipod ***Erichthonius brasiliensis***. Scraped quadrats were recolonized primarily by hydroids, green algae and sponges. The spadefish (***Chaetodipterus faber***), sheepshead (***Archosargus probatocephalus***), crested blenny (***Hypleurochilus geminatus***), and high hat (***Equetus acuminatus***) were the predominant resident fishes associated with the structures. Gut analyses of 191 fish representing 27 species indicated that ***Chaetodipterus faber, Archosargus probatocephalus, Hypleurochilus geminatus, Eupomacentrus variabilis,*** and ***Equetus acuminatus*** feed extensively on the fouling community. The greater amberjack (***Seriola dumerili***) ate ***Hypleurochilus geminatus***, and so was trophically related to the fouling community. The benthic fauna directly below the structures was apparently enriched by the food resource represented by barnacles and other invertebrates dislodged from the structures. Several fouling species were found on shells on the bottom directly beneath the structures which did not occur on the structures themselves. Growth rates of several mollusks (***Pteria colymbus, Musculus lateralis, Anadara transversa, Aequipecten gibbus,***and ***Ostrea equestris***) were sufficiently rapid to permit adult size to be attained in less than one year. Significant differences in the proportion of meroplankton were found among stations and between samples taken during the day and those taken at night. A significant difference was also found between combined stations within the field and the control station. Thus the larvae of fouling invertebrates may make a significant contribution to the food of planktivorous fishes and nektonic invertebrates.

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INTRODUCTION

The fouling community, its planktonic larvae and its predators have been under investigation at Buccaneer Field since May, 1976 in an effort to determine (1) the structure and the factors regulating the structure of the fouling community and (2) the pathways through which energy is exported from this community. Offshore structures increase the availability of a limiting resource by providing a substrate for numerous sessile species and associated species. Although direct evidence is sparce, it is logical to assume that these organisms in turn may be extensively exploited as a food resource by fishes which are attracted to these artificial reefs. This potential food resource has three major components: (1) living adult organisms, which may be consumed by grazers, (2) their planktonic larvae, which may be consumed by larger zooplankters or by planktivorous fishes, and (3) detritus, which may settle to the bottom and be consumed by bottom-feeding fishes and invertebrates.

MATERIAL AND METHODS

I. The Study Area

Buccaneer Field is located about 50 km (30 miles) south of the lighthouse on Galveston's south jetty. Shell Oil Company has constructed 16 structures on the field: 2 production platforms and 14 well jackets. Two structures, Platform A and Jacket C (see Figure 1), were selected for study. Platform A was selected for its proximity to several of the well jackets, which are potential sources of colonists and predators. For contrast Jacket C was selected for its relative isolation. Both structures are located in about 21.5 m (70 ft.) of water overlying a silty sand substrate with sporadic clay outcrops.

A third site located about 8 km (5 miles) east of Platform A was selected as a control area. Since sessile fouling organisms are absent, this site was used primarily for comparison of zooplankton and fish abundances to those within the Field.

II. Field Methods

Most of the field work was conducted with SCUBA, using 2- or 3-man dive teams to collect samples and carry out field experiments on the structures. The field experiments were designed to examine the dynamic properties of the fouling community. The macroscopic component of the community was scraped away from selected portions of the structures. Using a rock hammer or chisel and sledge, we removed this component from zones 0.5 m (1.6 ft.) wide around each of three legs on each structure at the 3 m (10 ft.), 8 m (25 ft.), and 15 m (45 ft.) depths.

The legs selected were from the eastern sides of the structures, i.e. facing the control area. A portion of each zone about 20 x 30 cm was cleaned thoroughly with a wire brush and a stainless steel mesh cage measuring 16 x 12 x 2 cm was placed over the upper half of this area and fastened with 0.95 cm wide stainless steel bands around the leg. These bands were replaced with plastic bands in January, 1977 since the metal bands corroded rapidly when in contact with the structure legs. A wire cloth with 3.15 meshes to the cm was used for the cages.

Each cage enclosed two 8 x 12 cm quadrats and protected them from fish grazing. Two matching quadrats below the cage were thus exposed to fish predation. Each quadrat was sampled photogrammetrically using a Nikonos II underwater camera and strobe. Photographs of good quality have been obtained even when the water was very turbid (visability of less than 2 m). Similar photographs were taken of undisturbed quadrats for comparison.

Large qualitative (10 - 20 liter) samples were collected from the littoral zone, 8 m and 15 m depths at each structure to provide a taxonomic base for the photogrammetric surveys. These samples were supplemented by smaller samples from 5, 11, 18 and 21 m depths and by miscellaneous collections of species not previously encountered.

Fish were collected by spear, slurp gun, hook and line, and by trapping blennies in barnacle shells. Additional fish guts were provided by Ian Workman and Carl Jones. Benthic invertebrates were collected by hand. Samples of fish (*Chaetodipterus faber* and *Hypleurochilus geminatus*) and barnacles (*Balanus tintinnabulum*) were collected for other work units. Algal samples were not provided because the algae encountered were grazed so close to the substrate that isolation of sufficiently large samples was not feasible.

Plankton tows were taken with 0.5 m conical nets equipped with digital flowmeters. Two mesh sizes were used: 243 µm (#6) and 80 µm (#20). The #20 net was towed for one minute and the #6 net for two minutes at a speed just sufficient to keep the top of the net at (but not breaking) the surface. Nannoplankton samples were taken with a 1.0 liter Kemmerer Sampler just below the surface of the water. All samples were preserved in 5% formalin in the field.

On May 24, 1976 ten replicate samples were taken with each net and with the Kemmerer Sampler at Platform A (see cruise schedule, Table 1). On 3 June, 22 June and 10 August 1976 ten replicate samples were taken with the Kemmerer Sampler and five replicate tows were made with each net at Platform A, Jacket C and the Control area. All samples on these dates were taken during daylight. On October 1-2, November 2 and December 9, 1976 five replicate tows were taken with each net at each station at night in addition to the daylight sampling pattern used previously.

III. Laboratory Methods

Color transparencies of the 8 x 12 cm quadrats were projected onto a wall from a distance calibrated to produce an image 16 x 24 cm in size. Identifiable organisms and taxa (e.g hydroids) were traced onto a piece of white paper, and the area of each object was measured with a compensating polar planimeter to the nearest 0.4 cm^2 (i.e. to the nearest 0.1 cm^2 on the original scale). Areas occupied by each species were summed and converted to a proportion of the total area.

Fish guts were stored frozen or, more rarely, in formalin until their contents could be examined. Identification of invertebrates in the guts was facilitated by comparisons to preserved specimens of invertebrates collected from Buccaneer Field. This comparison was especially valuable when only fragments of organisms were found in the guts. Fish scales were stained with rose bengal to aid ring counting. Standard lengths were measured with a meter stick to the nearest 0.2 cm. Wet weights were measured with a hand-held scale to the nearest 25 g for the larger fish and on a Mettler balance to the nearest 0.001 g for the small fish (i.e. blennies).

Samples of fouling organisms were sorted and the specimens identified to the lowest possible taxon. Presence of ovigerous females or juveniles was noted. Spicules were isolated, mounted and measured as an aid in identifying the sponges. Specimens were identified in our laboratory and not sent to specialists; hence all identifications must be considered tentative.

The nannoplankton samples were allowed to settle undisturbed for at least 24 hours, and the excess volume was decanted. The samples were stained with rose bengal and further decanted to 10 ml. A 0.1 ml subsample was counted in a Palmer-Maloney counting cell.

The #20 net samples were stained with rose bengal and diluted to constant volume. Subsamples were taken with a Hensen-Stempel pipette so that at least 100 of the most abundant organism were counted. Whenever the samples were clogged heavily with phytoplankton, the dilution was increased to ensure that the small zooplankters could be distinguished among the heavy concentrations of filamentous algae. Four subsamples were counted from each sample.

In the #6 net samples, large organisms were counted from the whole sample or from a subsample sufficiently large that at least 100 individuals were counted. The sample was then treated in the same manner as the #20 net samples for the counting of the smaller zooplankters.

RESULTS AND INTERPRETATION

I. Structure of the Fouling Community

A list of the sessile invertebrates and associated motile invertebrates identified from the Buccaneer Field samples is presented in Table 2. Sixteen algal species and 101 invertebrates have been identified from the structures. Several taxa, most notably the ascidians and the anemones, were not identified to species due to lack of expertise in our laboratory. Each of these two taxa were represented by approximately 3-5 species in the samples.

The depths and structures at which each of the identified species were found are presented with their relative abundances in Table 3 . Since the largest samples were collected in the littoral zone and at 8 m and 15 m, these depths are disproportionately represented in the vertical profiles. These large samples were taken in June-July, 1976 and in January, 1977; hence the table is subdivided into summer and winter seasons.

A more quantitative view of the natural community was derived from the interpretation of photographs of undisturbed quadrats. Four photographic transects were run, each consisting of six quadrats at each of six depths (3, 6, 9, 12, 15 and 18 m). A starting point was selected haphazardly and the quadrats were adjacent to one another to avoid unnecessary bias on the part of the photographer. Transects were run at Platform A on November 1, 1976 and January 21, 1977; transects were run at Jacket C on January 22, 1977. Results are shown in Tables 4 to 7 . This technique has the limitation that only sessile species recognizable in photographs were included; however, these collectively represented most of the biomass on the structures.

Perhaps the most conspicuous structural feature of the Buccaneer Field fouling community is the abundance of the large barnacle *Balanus tintinnabulum*. This barnacle is often 3-4 cm in diameter and, when crowded, may be twice that high. Moreover, individuals are often found growing on top of one another, especially near the sea surface, yielding a three dimensional microhabitat which may be 10-15 cm thick. This undoubtedly contributes to the abundance of snapping shrimp, xanthid crabs, ophiuroids, etc. on the upper portions of the structures. Twenty years ago *B. tintinnabulum* was an incidental species on Texas offshore oil field structures (Gunter and Geyer, 1955), and it has remained so on similar structures in Louisiana which are older than those at Buccaneer Field (Thomas, 1975). However, it may occupy as much as 77% of the original substrate on Buccaneer Field structures (Table 7).

Unoccupied habitat was extremely rare in natural quadrats and consisted almost entirely of scars left by dislodged barnacles or oysters. Occupied habitat was typically exploited by several layers of organisms. Barnacles appear to be the most perennial inhabitants. A variety of sponges, hydroids and algae appear to be among the earliest colonizers. The species diversity on Buccaneer Field structures is apparently intermediate between Louisiana platforms of similar age (Thomas, 1975) and the fouled floats studied off the Florida Gulf coast by Pequegnat and Pequegnat (1968). However, sampling as extensive as that of the latter study may yield a longer species list for Buccaneer Field.

Recolonization patterns were studied through the use of denuded quadrats and denuded and caged quadrats. Attempts to establish these quadrats during the summer months were unsuccessful due to our inability to return to Buccaneer Field before the bands supporting 50% of our cages had corroded off and the remaining cages had become so badly fouled that the data from these quadrats did not represent the phenomena under study. Better sampling and a new banding technique resulted in a successful effort during the winter.

Nine quadrats representing summer colonization at 15 m on Jacket C (Table 8) indicate that sponges, hydroids and the erect bryozoan *Savignyella lagonti* were the major colonists at this time. The hydroids and bryozoans were typically found growing over the sponges.

Two series of experiments were completed during the winter. Sets of experimental quadrats were established on both structures on September 30 - October 1, 1976. Those on Jacket C were monitored on December 29, 1976 and March 8, 1977; those on Platform A were monitored on January 21, 1977 and March 8, 1977. These quadrats were established only at the 8 m and 15 m depths. A second set of quadrats was established at the 3 m, 8 m and 15 m depths on both structures on January 21 - 22, 1977. Results are presented in Tables 9 to 14.

Initial colonists on uncaged quadrats on Jacket C were green algae, hydroids and sponges, all of which were less abundant in caged quadrats, presumably due to reduced light and planktonic food levels within the cages. Only *Savignyella lafonti* was noticeably more abundant in the cages, where it may have been encouraged by reduced fish predation. *S. lafonti* was found in gut contents of *Chaetodipterus faber*, one of the most abundant resident fishes.

The major barnacle colonists observed during the study were *Balanus improvisus* and *Balanus* (*amphitrite* complex), *Balanus tintinnabulum* being rarely observed. In general barnacle colonists were rare, as were barnacle larvae in the plankton samples. Since these observations encompass nearly a year, they suggest that successful sets by the dominant barnacle may not occur annually.

Subsequent (March 8) observations of the first set of Jacket C quadrats indicate an increased abundance of red algae on the uncaged quadrats and of the encrusting bryozoan *Parasmittina trispinosa* at the 15 m depth in both caged and uncaged quadrats. Relatively little colonization occurred on the second set of quadrats, that which occurred being primarily hydroids and green algae.

The first set of experimental quadrats on Platform A were also colonized by hydroids, sponges and green algae, with *Parasmittina trispinosa* and the erect bryozoan *Bugula neritina* becoming more abundant with time. The second set of quadrats indicate a similar pattern at lower intensity, except without *Bugula rylandi* and with a greater abundance of ***Tubularia crocea.***

Several interesting differences between the two structures were observed. ***Savignyella lafonti*** was seasonally common on Jacket C but rare on Platform A. Similarly, ***Bugula neritina*** and ***Bugula rylandi*** were seasonally abundant on Platform A but very rare on Jacket C. During the winter a large bloom of the large hydroid ***Tubularia crocea*** occurred on Platform A but not on Jacket C. Similarly, the urchin ***Arbacia punctulata*** appeared and became moderately common on Jacket C during the winter but was not observed on Platform A.

Among the motile invertebrates, ***Pachygrapsus transversus*** and the isopod ***Dynamene perforata*** were distinctly littoral, and the tanaids and pycnogonids were predominately so. ***Neanthes succinea, Trypanosyllis gemmipara, Turritopsis nutricula, Anadara transversa, Ostrea equestris, Leucothoe spinicarpa, Caprella equilibra, Balanus tintinnabulum, Synalpheus fritzmeulleri, Menippe mercenaria, Bugula neritina,*** and ***Aetea anquina*** had rather broad vertical distributions. Hermit crabs, associated species, most gastropods, and ***Octopus*** were largely limited to the bottom. ***Erichthonius brasiliensis*** was the dominant tube-building amphipods observed, and it appeared to fare better under the protection of the cages than in the open (Table 10).

II. Fish populations

No visual fish surveys were conducted due to a shortage of shiptime during the summer and insufficient visability during the fall and winter. However, numerous fish were encountered by divers doing other tasks. The species encountered by divers were classified according to their resident status in Table 15 . ***Hypleurochilus gemminatus*** is a permanent resident occupying old barnacle shells. Both juveniles and adults were abundant and egg clusters were often found inside barnacle shells in both summer and winter. Both juvenile and adult ***Eupomacentrus variabilis*** were also common. This species is territorial and mildly aggressive toward divers. Juvenile ***Epinephelus itajara*** were occasionally seen, and adults rarely, the latter apparently being more demersal.

Chaetodipterus faber was one of the most abundant and conspicuous fish observed. Its juveniles typically live closer to shore and were not seen at Buccaneer Field. ***Archosargus probatocephalus*** was also abundant, but only as adults. ***Balistes capriscus*** and ***Monacanthus hispidus*** were much less common but were often attracted to the activities of the divers and thus were probably observed out of proportion to their abundances. The latter two species were only observed in summer and fall. ***Equetus acuminatus*** was common throughout the study near the bottom, and ***Lutjanus campechanus*** was commonly observed near the bottom in fall and winter.

Schools of ***Kyphosus sectatrix, Seriola dumerili,*** and ***Caranx crysos*** were occasionally observed within and adjacent to the structures. ***Priacanthus arenatus*** and ***Rachycentron canadum*** were either rare residents or uncommon visitors.

Chaetodipterus faber, Archosargus probatocephalus and ***Hypleurochilus geminatus*** were selected for more thorough study because their abundance and relative ease of capture made obtaining large samples a reasonable expectation. Sample sizes to date are small, but some patterns have begun to emerge. Some of these patterns were also defined for ***Lutjanus campechanus*** and ***Equetus acuminatus.*** The relationship between standard length and wet weight is apparently exponential (Figures 2 to 6), and was such a good fit in some cases that taking both measurements may now be redundant. The relationship between age, as determined by counting scale rings, and standard length for ***Chaetodipterus faber*** was not so pleasing (Figure 7). This suggests that either growth rate is very variable or scale rings are a poor indicator of age in this species. ***Hypleurochilus geminatus*** is a naked blenny, and thus scale ring counts are impossible. Rings could not be discerned in cross-sections of dorsal spines, indicating that this may be a poor aging technique or that this is an annual species.

III. Fish predation

Contents of the guts of 191 fish representing 27 species were examined in order to determine which species, if any, were predators of the fouling community. The results are presented in Table 16. Nearly all of the fish were collected by divers adjacent to the structures. Several specimens provided by Ian Workman were caught on long lines.

Guts of six species contained algae, although in one case (***Monacanthus hispidus***) such a small quantity was found that its ingestion may have been accidental. Algae comprised most of the gut contents of individuals of ***H. geminatus, E. variabilis, C. faber,*** and ***K. sectatrix. Polysiphonia*** sp. was the only identifiable alga found. The hydroids consumed included ***Obelia*** sp. Most bryozoans consumed were erect forms, such as ***Bugula neritina*** and ***Savignyella lafonti,*** but ***Membranipora*** sp. was found in one blenny gut. ***Bugula neritina*** was found in the guts of individual ***A. probatocephalus, C. faber,*** and ***E. variabilis. A. probatocephalus*** guts also contained ***Aetea anguina, Caprella equilibra, Erichthonius brasiliensis, Musculus lateralis, Chione grus, Isognomon bicolor, Chama macerophylla,*** and ***Pilumnus dasypodus.*** Hence this species apparently feeds extensively on the fouling community.

C. faber guts also contained ***Savignyella lafonti, Aetea anguina, Caprella equilibra, Neanthes succinea, Trypanosyllis gemmipara, Musculus lateralis, Ophiactis savignyi,*** and ***Clavelina*** sp., and thus also depended heavily on the fouling community for food. ***Lutjanus campechanus*** guts contained ***Balanus*** sp., ***Clio*** sp., ***Clavelina*** sp., and ***Callinectes*** sp. ***Equetus acuminatus*** guts contained ***Pseudomedaeus agassizi, Crepidula fornicata,***and ***Musculus lateralis. E. variabilis*** guts also contained

Bugula neritina and ***Caprella equilibra***. One juvenile ***C. ocellatus*** caught during the winter at Jacket C had three individual ***Eupomatus protulicola*** in its gut. Thus these species, with the possible exception of the red snapper, apparently use the structures as a source of food. One ***Seriola dumerili*** gut contained five ***Hypleurochilus geminatus***, establishing a trophic link with the structures. In general (i.e. at the family level) these results agree with those of Randall (1967) and Earle (1972).

IV. Interactions with the bottom fauna

Most of our bottom dives were scheduled to recover pieces of equipment dropped during previous dives, and in so doing we recovered a variety of invertebrates. Many of these species, which were moderately common directly beneath the structure, were rarely observed by divers working away from the structures (Don Harper, pers. com.). Moreover, the sea floor beneath the structures was littered with barnacle shells, suggesting that the gastropods and hermit crabs found there had come to exploit a food resource falling from above. This was characteristic of both Platform A and Jacket C; thus the attraction was more than discarded edible garbage (which would be rare at Jacket C). This represents another pathway through which energy may be exported from the fouling community.

Another relevant feature of this bottom fauna is that most of the gastropod shells, many of which contain hermit crabs, were heavily encrusted with fouling organisms. One ***Thais haemastoma*** shell occupied by ***Dardanus fucosus*** contained over 20 commensal or fouling species. These included some which have not been found on the structures, such as ***Chelonibia patula***, ***Lepidonotus sublevis*** and ***Porcellana sayana***. These shells are a potential source of immigrants to the structures, but some species apparently have not yet made the transition.

V. Growth rates and breeding seasons

Very few organisms (e.g. barnacles) whose growth could be followed in the photographs settled on the experimental quadrats. The mean area covered by 11 ***Balanus*** (***amphitrite*** complex) individuals measured 159 days after the quadrat was scraped was 0.134 ± 0.014 cm^2, suggesting a minimum growth rate of 0.026 cm^2 per month.

The cages on Jacket C were changed on December 29, 1976, and those on Platform A were changed on January 21, 1977. Several species had fouled the cages, and thus their minimum growth rates could be estimated from measurements of individuals returned to the laboratory. The sizes and estimated minimum growth rates of several mollusks and one bryozoan are presented in Table 17 . These data are compared in the table to the size of the largest individual collected at Buccaneer Field and to the adult size reported in the literature (Andrews, 1971) to determine what proportion of the adult size had been attained.

The presence of ovigerous amphipods, isopods and decapods in the samples was noted in an effort to determine breeding seasons. Ovigerous ***Jassa falcata*** were observed in October and January, ***Leucothoe spinicarpa*** in June, ***Erichthonius brasiliensis*** in July, December and January, ***Caprella equilibra*** in June and January, and ***Stenothoe gallensis*** in January. Ovigerous ***Tanais*** sp. were observed in July, October and January. Ovigerous ***Synalpheus fritzmeulleri*** were observed in May, July, September, October, and numerous juveniles were observed in January. Ovigerous ***Hexapanopeus paulensis*** were observed in September, ***Pilumnus dasypodus*** in September, ***Porcellana sayana*** in September, ***Pachygrapsus transversus*** in June and July, ***Menippe mercenaris*** included numerous juveniles throughout the year but was never observed with eggs, ***Pseudomedaeus agassizi*** in September, November and January, ***Stenorynchus seticornis*** in October, and ***Panopeus turgidus*** in January. Thus a large portion of these taxa breed during the winter months.

VI. Zooplankton

Table 18 contains a list of the species identified from the zooplankton samples, and Table 19 indicates which of these taxa are counted from each sample type. For ease of comparison all counts have been converted to numbers of individuals per m^3. Tables 20 and 21 contain the means and standard errors for the densities of holoplankton and meroplankton, respectively, from the #6 net samples. Tables 22 and 23 contain the means and standard errors for the densities of holoplankton and meroplankton, respectively, from the #20 net samples. The means and standard errors of the densities of meroplankton in the Kemmerer water samples are presented in Table 24.

The #6 and #20 net samples were paired in chronological order, and the densities of holoplankton and meroplankton were pooled within each pair. This procedure was necessary since most of the holoplankton were counted in the #6 net samples and most of the meroplankton were counted in the #20 net samples. The means and standard errors of the proportions of meroplankton in these sample pairs are presented in Table 25. The nannoplankton samples were not pooled with the others because the densities of meroplankton were several orders of magnitude higher in these samples and because many of these meroplankters may have been derived from sources other than the structures.

The proportions of meroplankton for each station and date are illustrated in Figure 8 . To facilitate statistical comparisons between these samples the proportions were first transformed using an angular transformation (x' = arcsine of the square root of x). Analysis of variance (ANOVA) was used to test for differences among stations and between day and night samples. Significant differences in the proportion of meroplankton among stations were found ($F = 7.061$, $df = 2, 84$, $p < .001$). An a priori test was used to test for differences between the combined stations within the field and the control station, 8 km east of the field. A significant difference in the proportion of meroplankton was found ($F = 4.822$, $p < .05$). A significant difference in the proportion of meroplankton was also found between the day samples and the night samples during the winter ($F = 7.974$, $df = 1, 88$, $p < .01$).

Differences among the stations in holoplankton density ($F = 3.001$, $df = 2, 84$, $.05 < p < .10$) and in meroplankton density ($F = 3.197$, $df = 2, 84$, $.05 < p < .10$) were not significant. The proportion of meroplankton was higher in the field than in the control area, indicating that the larvae of fouling invertebrates and associated motile invertebrates represent a potentially significant food resource for planktivorous fish and nektonic invertebrates.

LITERATURE CITED

Andrews, J. 1971. Sea shells of the Texas coast. Univ. of Texas Press, Austin.

Earle, S. A. 1972. The influence of herbivores on the marine plants of Great Lameshur Bay, with an annotated list of plants. Natur. Hist. Mus. Los Angeles Co., Sci. Bull. 14:17-44.

Gunter, G., and R. A. Geyer, 1955. Studies on fouling organisms of the northwest Gulf of Mexico. Publ. Inst. mar. Sci. 4:37-87.

Pequegnat, W. E., and L. H. Pequegnat, 1968. Ecological aspects of marine fouling in the northeastern Gulf of Mexico. Ref. No. 68-22T, Dept. Oceanography, Texas A&M Univ. 80 p.

Randall, J. E. 1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr. Miami, No. 5:665-847.

Thomas, P. J. 1975. The fouling community on selected oil platforms off Louisiana, with special emphasis on the Cirripedia fauna. M.Sc. Thesis, Florida State Univ. vi. + 129 p.

APPENDIX

Table 1. Schedule of cruises to Buccaneer Field for 1976-77.

Date(s)	Location(s)	Activity	Vessel
May 11	Buoy #3	Diving to test re-entry ladder	R/V Seabob
May 18	A	Diving (aborted due to high seas)	R/V Seabob
May 24	A	Diving; plankton sampling	R/V Seabob
June 3	A, C, Control	Plankton sampling	R/V Seabob
June 17	A	Diving	R/V Seabob
June 22	A, C, Control	Plankton sampling	R/V Seabob
July 19	A, C	Diving	R/V Seabob
July 23	C	Diving	R/V Kingfish
Aug. 10	A, C, Control	Plankton sampling	R/V Kingfish
Sept. 13	A	NOAA check-out dives	R/V Seabob
Sept. 24	C	NOAA check-out dives	R/V Seabob
Sept. 30-Oct. 2	A, C, Control	Diving; plankton sampling	R/V Kingfish
Nov. 1	A	Diving	R/V Kingfish
Nov. 2	A, C, Control	Plankton sampling	R/V Kingfish
Nov. 23	A	Diving (aborted due to high seas and poor visability)	R/V Rachel Carson
Dec. 9	A, C, Control	Plankton sampling	R/V Rachel Carson
Dec. 29-30	C	Diving	R/V Rachel Carson
Jan. 21-22	A, C	Diving	R/V Gus III
Mar. 8	A, C	Diving	R/V Gus III

A = Platform A; C = Jacket C; Control = eastern control area; Buoy #3 is located at the entrance to the Houston Ship Channel.

Table 2. List of algae and benthic invertebrates collected at Buccaneer Field.

- Chlorophyceae
  - Cladophoraceae
    - *Cladophora delicatula*
    - *Cladophora vagabunda*
    - *Cladophora catenifera*
    - *Chaetomorpha media*
  - Ulvaceae
    - *Enteromorpha lingulata*
    - *Enteromorpha flexuosa*
  - Derbesiaceae
    - *Derbesia vaucheriaeformis*
  - Bryopsidaceae
    - *Bryopsis plumosa*

- Phaeophyceae
  - Ectocarpaceae
    - *Giffordia mitchelliae*

- Rhodophyceae
  - Gelidiaceae
    - *Gelidium pusillum*
  - Rhodomelaceae
    - *Polysiphonia denudata*
    - *Polysiphonia subtilissima*
    - *Centrocerus clavulatum*
    - *Bangia fuscopurpurea*
  - Ceramiaceae
    - *Callithamnion byssoides*
    - *Ceramium byssoideum*

- Porifera
  - Calcarea
    - Homocoelidae
      - *Clathrina* sp.
      - *Leucosolenia botryoides*
    - Heterocoelidae
      - *Scypha* sp.
      - *Leuconia* sp.
  - Demospongiaria
    - Spongiidae
    - Haliclonidae
      - *Haliclona permollis*
      - *Haliclona viridis*
      - *Haliclona loosanoffi*
      - *Haliclona* sp.
    - Renieridae
    - Halichondriidae
      - *Halichondria bowerbanki*
    - Hymeniacidonidae
      - *Hymeniacidon heliophila*
    - Suberitidae
      - *Prosuberites microsclerus*
    - Clionidae
      - *Cliona celata*
      - *Cliona vastifica*

- Hydrozoa
  - Clavidae
    - *Turritopsis nutricula*
  - Campanularidae
    - *Obelia dichtoma*
    - *Obelia hyalina*
    - *Clytia cylindrica*
  - Hydractinidae
    - *Stylactis* sp.
  - Corynidae
    - *Syncoryne eximia*
  - Eudendridae
    - *Eudendrium eximium*
  - Plumularidae
    - *Plumularia diaphana*
  - Tubularidae
    - *Tubularia crocea*

- Anthozoa
  - Ceriantharia
  - Actiniaria
    - Actiniidae
    - Aiptasiidae
    - Aiptasiomorphidae
  - Gorgonacea
    - *Leptogorgia virgulata*
  - Madreporaria
    - *Astrangia* sp.

- Rhynchocoela

- Turbellaria

- Polychaeta
  - Nereidae
    - *Neanthes succinea*
  - Polynoidae
    - *Lepidonctus sublevis*
    - *Lepidonctus variabilis*

Table 2. (Continued)

Syllidae
    Trypanosyllis gemmipara
    Haplosyllis spongicola
Eunicidae
    Eunice sp.
Lumbrineridae
    Lumbrineris sp.
Serpulidae
    Eupomatus dianthus
    Eupomatus protulicola
    Spirobranchus giganteus
Terebellidae
    Thelepus setosus
Sabellidae
    Sabella microphthalma

Gastropoda
  Dotoidae
    Doto sp.
  Calyptraeidae
    Crepidula plana
    Crepidula fornicata
  Columbellidae
    Mitrella lunata
  Olividae
    Oliva sayana
  Fasciolariidae
    Pleuroploca gigantea
  Buccinidae
    Cantharus cancellarius
  Muricidae
    Thais haemastoma
    Murex fulvescens
  Cerithiopsidae
    Seila adamsi
  Cypraeidae
    Cypraea spurca acicularis
  Ovulidae
    Neosimnia acicularis
  Epitoniidae
    Epitonium albidum
  Turridae
    Mangelia cf. *M. oxytata*

Pelecypoda
  Mytilidae
    Lithophaga bisulcata
    Lithophaga aristata
    Brachidontes exustus
  Mytilidae
    Musculus lateralis
  Arcidae
    Anadara transversa
    Arca imbricata
  Chamidae
    Chama macerophylla
  Pteridae
    Pteria colymbus
  Ostreidae
    Ostrea equestris
    Crassostrea virginica
  Pectinidae
    Aequipecten gibbus
  Isognomonidae
    Isognomon bicolor
  Veneridae
    Chione grus
  Limidae
    Lima pellucida
  Pinnidae
    Atrina seminuda
  Pholadidae
    Diplothyra smythi

Cephalopoda
  Octopodidae
    Octopus sp.

Pycnogonida
  Tanystylidae
    Tanystylum orbiculare

Amphipoda
  Ischyroceridae
    Jassa falcata
  Leucothoidae
    Leucothoe spinicarpa
  Corophiidae
    Erichthonius brasiliensis
    Corophium sp.
  Caprellidae
    Caprella equilibra
  Gammaridae
    Elasmopus sp.
  Stenothoidae
    Stenothoe gallensis

Isopoda

Table 2. .(Continued)

- Tanaidae
  - *Tanais sp.*
- Sphaeromidae
  - *Dynamene perforata*

- Cirripedia
  - Chthamalidae
    - *Chthamalus fragilis*
  - Balanidae
    - *Balanus tintinnabulum*
    - *Balanus improvisus*
    - *Balanus* (*amphitrite* complex)
    - *Chelonibia patula*

- Decapoda
  - Alpheidae
    - *Synalpheus fritzmeulleri*
  - Diogenidae
    - *Petrochirus diogenes*
    - *Dardanus fucosus*
    - *Paguristes puncticeps*
  - Paguridae
    - *Pagurus impressus*
    - *Pylopagurus holthuisi*
  - Majidae
    - *Stenorynchus seticornis*
  - Porcellanidae
    - *Porcellana sayana*
  - Dromiidae
    - *Dromidia antillensis*
  - Grapsidae
    - *Pachygrapsus transversus*
  - Portunidae
    - *Portunus gibbesii*
    - *Callinectes similis*
    - *Cronius ruber*
  - Xanthidae
    - *Menippe mercenaria*
    - *Hexapanopeus paulensis*
    - *Pilumnus dasypodus*
    - *Pseudomedaeus agassizi*
    - *Panopeus turgidus*
    - *Pilumnus pannosus*

- Bryozoa
  - Bugulidae
    - *Bugula neritina*
    - *Bugula rylandi*
  - Savignyellidae
    - *Savignyella lafonti*
  - Schizoporellidae
    - *Schizoporella errata*
  - Scrupariidae
    - *Eucratea loricata*
  - Smittinidae
    - *Parasmittina trispinosa*
  - Membraniporidae
    - *Membranipora tenuis*
    - *Membranipora savartii*
  - Aeteidae
    - *Aetea anguina*

- Ophiuroidea
  - Ophiothricidae
    - *Ophiothrix angulata*
  - Ophiactidae
    - *Ophiactis savignyi*

- Echinoidea
  - Arbaciidae
    - *Arbacia punctulata*

- Ascidiacea
  - Enterogona

Table 3. Seasonal and vertical distributions of algae and invertebrates.

Depth interval[1]	lit.				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure[2]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Cladophora delicatula	P	P	P	P							P																					
Cladophora vagabunda		P	P																													
Cladophora catenifera			P																													
Chaetomorpha media	P																															
Enteromorpha lingulata	P		P																													
Enteromorpha flexuosa	P																															
Derbesia vaucheriaeformis	P		P								P						P															
Bryopsis plumosa	P																															
Giffordia mitchelliae	P																															
Gelidium pusillum	P	P																														
Polysiphonia denudata	P		P								P	P																				
Polysiphonia subtilissima	P								P		P	P											P									
Centrocerus clavulatum			P	P																												
Bangia fuscopurpurea		P		P																												
Callithamnion byssoides		P	P						P		P	P					P				P											
Ceramium byssoideum	P		P																													
Clathrina sp.	P																															
Leucosolenia botryoides	P		P						P																							
Scypha sp.	P		P						P												P											
Leuconia sp.	P		P																													
Haliclona sp.											P																					
Haliclona permollis									P												P											
Haliclona viridis					P				P																							
Haliclona loosanoffi	P				P				P								P				P		P		P							
Halichondria bowerbanki	P								P								P				P											
Hymeniacidon heliophila											P																					
Prosuberites microsclerus											P																					
Cliona celata									P																							
Cliona vastifica									P																							
Turritopsis nutricula			C		C				C	U	A	U									C	U	C		R							
Obelia dichtoma				C								C					U				R											

Table 3. (continued).

Depth interval	lit.				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Obelia hyalina			C																													
Clytia cylindrica																	A															
***Stylactis* sp.**	R		U																													
Syncoryne eximia		A		A																												
Eudendrium eximium																					U					R						
Plumularia diaphana																					R				R		R					
Tubularia crocea		C								A							C															
Leptogorgia virgulata									R						R												R					
***Astrangia* sp.**																									R	R	U	U				
Neanthes succinea	C	C	C	U	C				A	C	A	A					U				A	A	C	U	R							
Lepidonotus sublevis																															R	
Lepidonotus variabilis									R												R		R									
Trypanosyllis gemmipara	C	R	U	U	A				A	U	A	U					U				C	R	C	U	U							
Haplosyllis spongicola	A		A		A				A	R	A	C					A					R	C	U	U							
***Eunice* sp.**	R										R												C	R								
***Lumbrineris* sp.**											R												R									
Eupomatus dianthus									R														U								C	
Eupomatus protulicola	U								R		R												R									
Spirobranchus giganteus																											R					
Thelepus setosus																					R											
Sabella microphthalma																																
Doto sp.			C								C												R									
Crepidula plana									R																						C	
Crepidula fornicata																													C	R	C	
Mitrella lunata																							R						R	R		
Oliva sayana																															U	
Pleuroploca gigantea																							R							R		
Cantharus cancellarius																															U	
Thais haemastoma																						R							R	U		
Murex fulvescens																													R		R	

Table 3. (continued).

Depth interval	lit.				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Seila adamsi																															U	
Cypraea spurca acicularis																														R		
Neosimnia acicularis																											R					
Epitonium albidum																														R		
Mangelia cf. *M. oxytata*																														R		
Lithophaga bisulcata		R	R	R							R		C								U	U	U								U	
Lithophaga aristata			R	R						R			C								R		R									
Brachidontes exustus	R																															
Musculus lateralis	R		R	C					R	A	R	C										C	U	C								
Anadara transversa	U		R		C				U	R	R		C										U								U	
Arca imbricata									U		R																					
Chama macerophylla	R		U	R					U	R	R	R	R									U	U	R							C	
Pteria colymbus									R	R	R							R					R									
Ostrea equestris	R		R			A			R	U		R	C								R	U	U	R	U						U	
Crassostrea virginica											R																					
Aequipecten gibbus									R																							
Isognomon bicolor	A	C	A	A	C				A	C	U	U	C									U		R								
Chione grus			R						U		R												R						U			
Lima pellucida									R																							
Atrina seminuda																								R								
Diplothyra smythi																															C	
Octopus sp.																														R		
Tanystylum orbiculare	A		A								C																					
Jassa falcata		A	A	A	C				R	U	R										R											
Leucothoe spinicarpa					C				A	C			R								A	C	A	C								
Erichthonius brasiliensis				U						C		C	C								C	C	C	U								
Corophium sp.																					C											
Caprella equilibra	A	A	C	A	A				A	A	A	R	C								C	U			U							
Elasmopus sp.		A	A	C						R	C	R												R								

Table 3. (continued).

Depth interval	lit.				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Stenothoe gallensis		C	C	R						U	C	R										R		R								
Tanais sp.	A	A	A	U	C						A																					
Dynamene perforata	A	C	A	C																												
Chthamalus fragilis			R																													
Balanus tintinnabulum	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	U	U	U	U				
Balanus improvisus											R																					
Balanus (*amphitrite* complex)			C						U				R												U						R	
Chelonibia patula																															U	
Synalpheus fritzmeulleri			U	C	A				A	A	A		U				R				A	A	A	C	U							
Petrochirus diogenes																															C	
Dardanus fucosus																															C	
Paguristes puncticeps																															U	
Pagurus impressus																															C	
Pylopagurus holthuisi																															U	
Stenorynchus seticornis																							R	R								
Porcellana sayana																															C	
Dromidia antillensis											C										C		U									
Pachygrapsus transversus	U	U	U	C																												
Portunus gibbesii			U																													
Callinectes similis			U																													
Cronius ruber											R	R																				
Menippe mercenaria	R	U	C	R	A				C	R	C	R	U				C				R	R			C							
Hexapanopeus paulensis	R								C		C										C		A							R	C	
Pilumnus dasypodus	R								R				R								R	R	R								U	
Pilumnus pannosus													R																			
Pseudomedaeus agassizi													A								C	A	A	C	C					R	C	
Panopeus turgidus											R																			R		

Table 3. (continued).

Depth interval	lit.				3-6 m				6-9 m				9-12 m				12-15 m				15-18 m				18-21 m				btm.			
Season/structure	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Bugula neritina		R		U	R				A	C			A								A	C			R							
Bugula rylandi									U	U			C								U	U										
Savignyella lafonti		R											C								A	R	A				R					
Schizoporella errata									C		C	U	U												U							
Eucratea loricata																											U					
Parasmittina trispinosa										R												U					R					
Membranipora tenuis	U																															
Membranipora savartii									R			R																				
Aetea anguina	A	C			U				C				C								C	U			C							
Ophiothrix angulata									R		R	R																				
Ophiactis savignyi	A	U		C					A	A	R		C								A	C		R								
Arbacia punctulata												U												U								

[1] lit. = littoral; btm. = bottom

[2] 1 = Platform A in summer; 2 = Platform A in winter; 3 = Jacket C in summer; 4 = Jacket C in winter

P = present; A = abundant; C = common; U = uncommon; R = rare

Table 4. Proportion of space occupied by various fouling species in undisturbed photogrammetric quadrats on November 1, 1976 on Platform A.

	Depth									
	6 m		9 m		12 m		15 m		18 m	
Species	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.079	.050	.233	.083	.592	.073	.293	.098	.004	.004
Bugula neritina	.023	.020	.015	.010	.040	.028	.014	.009	0	
Savignyella lafonti	0		0		.974	.017	.982	.008	0	
Ostrea equestris	.318	.162	0		0		0		0	
Astrangia sp.	0		0		0		0		.002	.002
Haliclona permollis	.015	.015	.015	.015	.014	.014	0		0	
Haliclona loosanoffi	.160	.160	.245	.166	.473	.213	.991	.006	0	
Haliclona sp.	.797	.161	.595	.180	.155	.155	0		.824	.074
hydroids	.932	.031	.984	.007	0		0		0	
green algae	.932	.031	.958	.028	.974	.017	.982	.008	0	
serpulids	0		.017	.016	0		0		0	
sponge (red)	0		0		0		0		.172	.069
bare substrate	.006	.006	0		0		0		.002	.002

[1] mean of six replicates; [2] standard error

Table 5. Proportion of space occupied by various fouling species in undisturbed photogrammetric quadrats on January 21, 1977 on Platform A.

	Depth											
	3 m		6 m		9 m		12 m		15 m		18 m	
Species	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.389	.115	.324	.072	.145	.052	.208	.040	.121	.047	.033	.023
Bugula neritina	.028	.021	.119	.038	.147	.059	.094	.050	.071	.028	.037	.037
Bugula rylandi	0		.001	.001	.076	.055	.185	.130	.020	.015	.015	.015
Savignyella lafonti	0		0		.003	.003	0		0		0	
Parasmittina trispinosa	0		.001	.001	.004	.004	0		0		0	
Ostrea equestris	0		0		0		.001	.001	0		0	
Astrangia **sp.**	0		0		0		0		0		.002	.002
Tubularia crocea	.090	.035	.187	.048	.025	.021	0		0		0	
Haliclona permollis	.662	.151	0		0		0		0		0	
Haliclona loosanoffi	0		0		0		0		.731	.151	.800	.163
Haliclona **sp.**	.128	.128	.637	.039	.721	.063	.428	.186	.167	.167	.167	.167
hydroids	.759	.072	.663	.061	.696	.074	.645	.126	.731	.151	.856	.068
red algae	.014	.009	0		0		0		.012	.012	0	
green algae	.022	.022	0		0		0		0		0	
compound ascidian (transparent)	0		.013	.013	0		.407	.189	0		0	
compound ascidian (orange)	0		.003	.003	.034	.034	0		0		0	
sponge (red)	0		0		0		0		0		.031	.027

[1] mean of six replicates; [2] standard error

Table 6. Proportion of space occupied by various fouling species in undisturbed photogrammetric quadrats on January 22, 1977 on leg B1 of Jacket C.

	Depth											
	3 m		6 m		9 m		12 m		15 m		18 m	
Species	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.485	.130	.583	.111	.190	.103	.433	.142	.175	.066	.105	.048
Parasmittina trispinosa	.003	.003	.011	.011	.027	.027	0		0		.006	.006
Ostrea equestris	.030	.019	0		.015	.015	0		.006	.006	0	
Haliclona permollis	0		0		.027	.027	0		.125	.125	0	
Haliclona loosanoffi	0		.582	.160	.392	.164	.498	.167	.709	.171	.762	.194
Haliclona sp.	.839	.095	.381	.156	.404	.163	.385	.198	.100	.100	.181	.181
hydroids	.949	.051	.908	.042	.741	.151	.691	.114	.932	.027	.908	.092
red algae	.063	.039	.006	.006	0		0		0		0	
green algae	.059	.034	0		0		0		0		0	
compound ascidian (transparent)	0		0		0		0		.025	.025	.032	.032
sponge (orange)	0		.007	.006	0		.117	.063	0		0	

[1] mean of six replicates; [2] standard error

Table 7. Proportion of space occupied by various fouling species in undisturbed photogrammetric quadrats on January 22, 1977 on leg B2 of Jacket C.

Species	Depth											
	3 m		6 m		9 m		12 m		15 m		18 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus tintinnabulum	.392	.151	.682	.112	.529	.087	.771	.098	.386	.072	.255	.161
Bugula neritina	0		0		0		0		.052	.052	.141	.119
Parasmittina trispinosa	0		.007	.004	.006	.006	0		0		0	
Ostrea equestris	0		0		0		.006	.006	.013	.013	0	
Haliclona permollis	.318	.318	.694	.188	.332	.210	0		0		0	
Haliclona loosanoffi	.156	.156	0		.055	.052	.029	.018	.651	.186	.405	.167
Haliclona sp.	.456	.259	0		.491	.220	.904	.030	.124	.124	.257	.170
hydroids	.930	.017	.948	.033	.941	.047	.942	.030	.646	.191	.765	.119
red algae	.076	.013	.010	.006	.051	.048	.005	.004	.002	.002	0	
compound ascidian (transparent)	0		0		0		0		.170	.098	.193	.113
sponge (orange)	.007	.007	0		0		.057	.031	.002	.002	0	

[1] mean of six replicates; [2] standard error

Table 8. Proportion of space occupied by various fouling species in experimental photogrammetric quadrats on Jacket C at the 15 m depth on September 13, 1976 (56 days after start of the treatment).

Species	$\bar{x}$[1]	s.e.[2]
Bugula neritina	.005	.005
Savignyella lafonti	.349	.091
Astrangia sp.	.002	.002
Haliclona permollis	.085	.032
Haliclona viridis	.003	.003
Haliclona sp.	.456	.114
hydroid	.110	.076
red algae	.003	.003
green algae	.039	.026
bare substrate	.189	.076

[1] mean of nine replicates; [2] standard error

Table 9. Proportion of space occupied by various fouling species in experimental photogrammetric quadrats on Jacket C on December 29, 1976 (90 days after start of the treatment).

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e	$\bar{x}$	s.e.
Balanus amphitrite complex	.049	.022	.007	.004	.065	.023	.002	.002
Balanus tintinnabulum	0		0		.002	.002	0	
Savignyella lafonti	.003	.003	.002	.002	.159	.054	.185	.089
Parasmittina trispinosa	.005	.004	.088	.048	.100	.045	.095	.049
Ostrea equestris	.004	.004	0		0		0	
Astrangia sp.	0		.001	.001	0		0	
Haliclona permollis	.052	.052	0		0		.004	.004
Haliclona loosanoffi	0		.036	.022	0		.025	.020
Haliclona sp.	.225	.109	.063	.052	.016	.016	0	
Leuconia sp.	0		0		.003	.002	0	
serpulids	0		.001	.001	.001	.001	.004	.002
hydroids	.661	.149	.303	.189	.018	.018	.186	.124
red algae	.001	.001	0		0		0	
green algae	.694	.145	.303	.189	.012	.012	.186	.124
sponge (orange)	0		0		0		.002	.002
compound ascidian (transparent)	0		0		.401	.190	.008	.005
bare substrate	.041	.041	.466	.148	.384	.062	.331	.136

[1] mean of six replicates; [2] standard error

Table 10. Proportion of space occupied by various fouling species in experimental photogrammetric quadrats on Jacket C on March 8, 1977 (159 days after start of the treatment).

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus amphitrite complex	0		.002	.001	.026	.015	.001	.001
Parasmittina trispinosa	.001	.001	.272	.101	.058	.053	.240	.090
Aetea anguina	0		0		.189	.147	0	
Haliclona permollis	0		0		0		.006	.006
Haliclona viridis	0		0		.010	.006	.056	.036
Haliclona loosanoffi	0		.013	.013	0		.128	.070
Haliclona sp.	.336	.208	.103	.062	0		.017	.017
hydroids	.509	.196	.296	.144	.067	.067	.281	.130
red algae	.341	.221	.134	.058	0		.020	.013
green algae	.696	.118	.049	.045	.009	.009	0	
serpulids	0		.002	.002	0		.002	.002
corophiid tubes	0		0		.067	.067	.153	.059
compound ascidian (transparent)	.036	.022	.117	.102	.481	.273	0	
bare substrate	.003	.003	.132	.084	.161	.066	.115	.048

[1] mean of six replicates; [2] standard error

Table 11. Proportion of space occupied by various fouling species in experimental photogrammetric quadrats on Jacket C on March 8, 1977 (46 days after start of the treatment).

Treatment	Scraped						Scraped and Caged					
Depth	3 m		8 m		15 m		3 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus improvisus	0		0		0		0		0		.001	.001
Balanus sp.	0		0		0		0		.001	.001	0	
Parasmittina trispinosa	0		.023	.023	.024	.020	0		0		.050	.039
Haliclona permollis	.022	.022	0		0		0		0		0	
Haliclona loosanoffi	0		0		.185	.128	0		0		0	
hydroids	.525	.201	0		.493	.150	.063	.050	.189	.144	.132	.084
red algae	.001	.001	.020	.020	.151	.066	0		.063	.043	.002	.002
green algae	.080	.044	.619	.068	0		.008	.007	.236	.133	0	
bare substrate	.444	.205	.339	.110	.423	.136	.926	.047	.675	.111	.815	.083

[1] mean of six replicates; [2] standard error

Table 12. Proportion of space occupied by various fouling species in experimental photogrammetric quadrats on Platform A on January 21, 1977 (113 days after start of the treatment).

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus **sp.**	.002	.002	0		0		.002	.002
Bugula neritina	.100	.036	.102	.040	.145	.064	.097	.062
Bugula rylandi	.066	.038	.022	.022	.067	.037	.082	.058
Parasmittina trispinosa	.111	.031	0		.033	.021	.006	.006
Ostrea equestris	.004	.004	0		.003	.003	0	
Chama macerophylla	0		0		0		.002	.002
Haliclona permollis	.283	.179	0		.122	.104	.344	.164
Haliclona viridis	0		0		.008	.005	0	
Haliclona **sp.**	.327	.172	.710	.180	.217	.164	.420	.195
Leuconia **sp.**	0		.002	.002	0		0	
Pteria colymbus	0		0		.001	.001	0	
hydroids	.727	.049	.874	.033	.435	.171	.811	.081
green algae	0		.874	.033	0		.266	.171
corophiid tubes	0		0		.159	.074	0	
compound ascidian (transparent)	.034	.034	0		.429	.168	.048	.048
bare substrate	0		0		.039	.039	0	

[1] mean of six replicates; [2] standard error

Table 13. Proportion of space occupied by various fouling species in experimental photogrammetric quadrats on Platform A on March 8, 1977 (159 days after start of the treatment).

Treatment	Scraped				Scraped and Caged			
Depth	8 m		15 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus amphitrite complex	.005	.002	0		.006	.006	0	
Balanus improvisus	0		0		.001	.001	0	
Bugula neritina	.296	.065	.483	.125	.252	.094	.434	.056
Bugula rylandi	.001	.001	.031	.025	.041	.013	.122	.059
Parasmittina trispinosa	.246	.078	0		.074	.060	.010	.010
Ostrea equestris	.005	.002	0		.002	.002	0	
Chama macerophylla	0		0		.001	.001	0	
Tubularia crocea	.019	.006	0		.001	.001	.003	.002
Haliclona loosanoffi	.019	.019	.412	.127	0		0	
Haliclona viridis	0		0		.002	.002	0	
Haliclona sp.	0		.043	.030	.061	.050	0	
hydroids	.411	.070	.444	.103	.541	.066	.435	.032
red algae	.032	.016	0		0		0	
green algae	.174	.102	0		0		0	
corophiid tubes	0		0		.108	.065	0	
bare substrate	.006	.005	0		0		0	

[1] mean of six replicates; [2] standard error

Table **14.** Proportion of space occupied by various fouling species in experimental photogrammetric quadrats on Platform A on March 8, 1977 (46 days after start of the treatment).

Treatment	Scraped						Scraped and Caged					
Depth	3 m		8 m		15 m		3 m		8 m		15 m	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Balanus improvisus	0		0		0		0		.004	.002	0	
Balanus sp.	.001	.001	0		0		.002	.001	0		0	
Bugula neritina	0		.031	.026	.030	.008	.002	.002	.011	.007	.038	.013
Parasmittina trispinosa	0		.016	.011	0		0		0		.004	.004
Tubularia crocea	.002	.002	.003	.003	0		.079	.033	.038	.020	.009	.009
Haliclona sp.	0		0		.013	.008	0		0		0	
hydroids	0		.087	.058	0		.137	.050	.066	.047	0	
red algae	.021	.021	.006	.006	0		.054	.033	.010	.010	0	
green algae	.172	.056	.011	.006	0		.174	.046	.002	.002	0	
corophiid tubes	.005	.005	0		0		0		0		0	
bare substrate	.801	.059	.847	.084	.957	.007	.742	.044	.870	.038	.949	.018

[1] mean of six replicates; [2] standard error

Table 15. Fishes observed by divers at Buccaneer Field.

I. Resident species

A. both adults and juveniles observed

Hypleurochilus geminatus (crested blenny)
Eupomacentrus variabilis (cocoa damselfish)
Epinephelus itajara (jewfish)
Equetus acuminatus (high hat)
Halichoeres caudalis (painted wrasse)

B. only adults observed

Chaetcdipterus faber (Atlantic spadefish)
Archosargus probatocephalus (sheepshead)
Rypticus saponaceus (greater soapfish)
Epinephelus nigritus (Warsaw grouper)
Epinephelus guttatus (red hind)
Scorpaena plumieri (spotted scorpionfish)

II. Summer residents

A. only juveniles observed

Abudefduf saxatilis (sergeant major)

B. only adults observed

Pomacanthus paru (French angelfish)
Holacanthus ciliaris (queen angelfish)
Balistes capriscus (gray triggerfish)
Monacanthus hispidus (planehead filefish)

III. Transient schooling species

Kyphosus sectatrix (Bermuda chub)
Seriola dumerili (greater amberjack)
Selene vomer (lookdown)
Caranx crysos (blue runner)
Lutjanus synagris (lane snapper)
Lutjanus campechanus (red snapper)
Priacanthus arenatus (bigeye)
Rachycentron canadum (cobia)
Scomberomorus maculatus (Spanish mackerel)
Scomberomorus cavalla (king mackerel)
Pomatomas saltatrix (bluefish)

IV. Species of uncertain status

Chaetodon ocellatus (common butterflyfish)
(one juvenile observed in winter)

Table 16. Proportion of fish guts from Buccaneer Field containing each prey type.

	No. guts examined	Proportion empty	Fouling organisms				
			red algae	green algae	sponge	hydroids	bryozoans
Chaetodipterus faber	58	.38	.02	.07	.02	.09	.14
Archosargus probatocephalus	28	0	.04	.21	0	.21	.25
Lutjanus campechanus	23	.09	0	0	0	0	0
Equetus acuminatus	17	.18	0	0	0	.06	.06
Hypleurochilus geminatus	12	0	.42	.25	.25	.42	.25
Pomatomas saltatrix	9	.78	0	0	0	0	0
Seriola dumerili	6	.50	0	0	0	0	0
Balistes capriscus	5	0	0	0	0	0	0
Carcharhinus acronotus	5	.40	0	0	0	0	0
Eupomacentrus variabilis	3	0	.33	.33	0	0	.33
Kyphosus sectatrix	3	0	.33	.33	0	0	0
Caranx crysos	3	.33	0	0	0	0	0
Epinephelus itajara	2	0	0	0	0	0	0
Rypticus saponaceus	2	0	0	0	0	0	0
Scomberomorus cavalla	2	0	0	0	0	0	0
Epinephelus nigritus	2	1.00	0	0	0	0	0
Monacanthus hispidus	1	0	1.00	0	0	0	1.00
Pomacanthus paru	1	0	0	0	0	0	0
Lutjanus synagris	1	1.00	0	0	0	0	0
Priacanthus arenatus	1	0	0	0	0	0	0
Rachycentron canadum	1	0	0	0	0	0	0
Echeneis naucrates	1	0	0	0	0	0	0
Chaetodon ocellatus	1	0	0	0	0	0	0
Halichoeres caudalis	1	0	0	0	0	0	0
Scorpaena plumieri	1	0	0	0	0	0	0
Scomberomorus maculatus	1	1.00	0	0	0	0	0
Epinephelus guttatus	1	1.00	0	0	0	0	0

Table 16. (continued).

	Fouling organisms						
	ascidians	barnacles w/o shells	barnacles w/ shells	caprellid amphipods	gammarid amphipods	isopods	polychaetes
Chaetodipterus faber	.03	.31	0	.05	.05	0	.03
Archosargus probatocephalus	0	.46	.36	.11	.14	.04	.04
Lutjanus campechanus	0	.13	0	0	0	0	0
Equetus acuminatus	0	.06	0	.24	.53	0	.06
Hypleurochilus geminatus	0	0	0	.42	.50	0	.08
Pomatomas saltatrix	0	0	0	0	0	0	0
Seriola dumerili	0	0	0	0	0	0	0
Balistes capriscus	0	.40	0	0	0	0	0
Carcharhinus acronotus	0	0	0	0	0	0	0
Eupomacentrus variabilis	.33	0	0	.33	.67	0	0
Kyphosus sectatrix	0	0	0	0	0	.33	0
Caranx crysos	0	0	0	0	0	0	0
Epinephelus itajara	0	0	0	1.00	1.00	.50	.50
Rypticus saponaceus	0	0	0	0	0	0	0
Scomberomorus cavalla	0	0	0	0	0	0	0
Epinephelus nigritus	0	0	0	0	0	0	0
Monacanthus hispidus	0	1.00	0	1.00	1.00	0	0
Pomacanthus paru	0	1.00	0	0	0	0	0
Lutjanus synagris	0	0	0	0	0	0	0
Priacanthus arenatus	0	.50	00	0	1.00	.50	0
Rachycentron canadum	0	0	0	0	0	0	0
Echeneis naucrates	0	0	0	0	0	0	0
Chaetodon ocellatus	0	1.00	0	0	0	0	1.00
Halichoeres caudalis	0	0	0	1.00	1.00	0	0
Scorpaena plumieri	0	0	0	0	0	0	0
Scomberomorus maculatus	0	0	0	0	0	0	0
Epinephelus guttatus	0	0	0	0	0	0	0

Table 16. (continued).

	Fouling organisms				Zooplankton		
	bivalves	ophiuroids	alpheids	xanthids	hyperiid amphipods	ostracods	pteropods
Chaetodipterus faber	.03	.03	0	0	.05	0	.03
Archosargus probatocephalus	.07	0	0	.07	0	0	0
Lutjanus campechanus	0	0	0	0	.04	0	.09
Equetus acuminatus	.18	0	0	.29	0	0	0
Hypleurochilus geminatus	0	0	0	0	0	0	0
Pomatomas saltatrix	0	0	0	0	0	0	0
Seriola dumerili	0	0	0	0	0	0	0
Balistes capriscus	0	0	0	.20	.20	0	.40
Carcharhinus acronotus	0	0	0	0	0	0	0
Eupomacentrus variabilis	0	0	0	.33	0	0	0
Kyphosus sectatrix	0	0	0	0	.33	0	0
Caranx crysos	0	0	0	0	.33	0	.33
Epinephelus itajara	0	0	0	0	0	0	.50
Rypticus saponaceus	0	0	0	0	0	0	0
Scomberomorus cavalla	0	0	0	0	0	0	0
Epinephelus nigritus	0	0	0	0	0	0	0
Monacanthus hispidus	1.00	1.00	1.00	1.00	0	0	0
Pomacanthus paru	0	0	0	0	0	0	0
Lutjanus synagris	0	0	0	0	0	0	0
Priacanthus arenatus	0	0	0	0	0	0	0
Rachycentron canadum	0	0	0	0	0	0	0
Echeneis naucrates	0	0	0	0	0	0	0
Chaetodon ocellatus	0	0	0	0	0	1.00	0
Halichoeres caudalis	0	0	0	0	0	0	0
Scorpaena plumieri	0	0	0	0	0	0	0
Scomberomorus maculatus	0	0	0	0	0	0	0
Epinephelus guttatus	0	0	0	0	0	0	0

Table 16. (continued).

	Zooplankton						
	gastrop. veligers	brachyura zoea	brachyura megalopa	fish larvae	fish scales	penaeids	stomatopods
Chaetodipterus faber	.02	.03	.02	.03	.03	0	.02
Archosargus probatocephalus	0	0	0	0	.11	0	.04
Lutjanus campechanus	0	0	.04	0	0	.13	.04
Equetus acuminatus	0	0	0	0	.06	.24	.06
Hypleurochilus geminatus	0	0	0	0	0	0	0
Pomatomas saltatrix	0	0	0	0	0	0	0
Seriola dumerili	0	0	0	0	0	0	0
Balistes capriscus	0	.20	.40	0	0	0	.20
Carcharhinus acronotus	0	0	0	0	0	.20	0
Eupomacentrus variabilis	0	0	0	0	.33	0	0
Kyphosus sectatrix	0	0	.33	0	0	0	0
Caranx crysos	0	.33	.33	0	0	0	0
Epinephelus itajara	0	0	0	0	0	0	0
Rypticus saponaceus	0	0	0	0	0	0	0
Scomberomorus cavalla	0	0	0	0	.50	.50	0
Epinephelus nigritus	0	0	0	0	0	0	0
Monacanthus hispidus	0	0	0	0	0	0	0
Pomacanthus paru	0	0	0	0	0	0	0
Lutjanus synagris	0	0	0	0	0	0	0
Priacanthus arenatus	0	0	.50	0	0	1.00	.50
Rachycentron canadum	0	0	0	0	0	0	0
Echeneis naucrates	0	0	0	0	0	0	0
Chaetodon ocellatus	0	0	0	0	0	0	0
Halichoeres caudalis	0	0	0	0	0	0	0
Scorpaena plumieri	0	0	0	0	0	1.00	0
Scomberomorus maculatus	0	0	0	0	0	0	0
Epinephelus guttatus	0	0	0	0	0	0	0

Table 16. (continued).

	Nekton & Benthos						
	portunids	porcellanids	Callianassa	gastropods	cephalopods	fish	unidentified
Chaetodipterus faber	0	0	0	0	0	0	.10
Archosargus probatocephalus	.46	0	0	0	0	.11	0
Lutjanus campechanus	.13	0	0	0	0	.30	.17
Equetus acuminatus	0	.06	0	.06	0	0	0
Hypleurochilus geminatus	0	0	0	0	0	0	.42
Pomatomas saltatrix	0	0	0	0	0	.20	0
Seriola dumerili	0	0	0	0	0	.50	0
Balistes capriscus	0	0	0	.20	.20	.40	0
Carcharhinus acronotus	0	0	0	0	0	.60	0
Eupomacentrus variabilis	0	0	0	.33	0	0	0
Kyphosus sectatrix	0	0	0	0	0	0	0
Caranx crysos	0	0	0	0	0	.33	.33
Epinephelus itajara	0	0	0	0	0	0	0
Rupticus saponaceus	0	0	.50	0	0	1.00	0
Scomberomorus cavalla	0	0	0	0	0	.50	0
Epinephelus nigritus	0	0	0	0	0	0	0
Monacanthus hispidus	0	0	0	0	0	0	0
Pomacanthus paru	0	0	0	1.00	0	0	0
Lutjanus synagris	0	0	0	0	0	0	0
Priacanthus arenatus	0	0	0	0	0	.50	0
Rachycentron canadum	1.00	0	0	0	0	0	0
Echeneis naucrates	1.00	0	0	0	0	0	0
Chaetodon ocellatus	0	0	0	0	0	0	0
Scorpaena plumieri	0	0	0	0	0	0	0
Scomberomorus maculatus	0	0	0	0	0	0	0
Epinephelus guttatus	0	0	0	0	0	0	0

Table 17. Measurements and estimated minimum growth rates of selected invertebrates fouling cages at Buccaneer Field.

Species	Structure	Date	n	$\bar{x}$[1]	s.e.	maximum size	minimum growth rate[2]	maximum size observed	reported size (Andrews, 1971)
Pteria colymbus	A	1/21	23	1.69	.09	2.56	.69	8.92	3.8 - 7.6
Pteria colymbus	C	12/29	12	1.59	.15	2.48	.83	8.92	3.8 - 7.6
Musculus lateralis	A	1/21	22	.65	.02	.82	.22	.76	1.00
Musculus lateralis	C	12/29	10	.59	.03	.69	.23	.76	1.00
Anadara transversa	A	1/21	1	.52	-	.52	.14	.97	1.2 - 3.6
Aequipecten gibbus	A	1/21	2	1.60	.09	1.69	.46	-	2.5 - 5.1
Ostrea equestris	A	1/21	1	1.60	-	1.60	.43	7.12	2.5 - 5.1
Ostrea equestris	C	12/29	1	.78	-	.78	.26	7.12	2.5 - 5.1
Parasmittina trispinosa	C	12/29	7	7.11	1.76	13.45	4.50	-	-

[1] mean length in cm for mollusks; mean area in cm^2 for *Parasmittina trispinosa*.

[2] in cm $month^{-1}$ for mollusks; in cm^2 $month^{-1}$ for *Parasmittina trispinosa*.

Table 18. List of invertebrate taxa encountered in zooplankton samples.

- Hydrozoa
  - *Obelia* sp.
  - *Liriope* sp.
  - *Phialidium* sp.
  - siphonophores
- Ctenophora
- Polychaeta
- Mollusca
  - Gastropoda
    - veligers
    - thecosomatous pteropods
      - *Clavelina* sp.
      - *Clio* sp.
  - Pelecypoda
    - veligers
  - Cephalopoda
    - juvenile squid
- Crustacea
  - Cladocera
    - *Penilia* sp.
    - Species B
  - Ostracoda
    - *Euconchoecia chierchiae*
  - Copepoda
    - Calanoida
      - *Undinula vulgaris*
      - *Eucalanus pileatus*
      - *Paracalanus parvus*
      - *Temora stylifera*
      - *Temora turbinata*
      - *Candacia curta*
      - *Centropages velificatus*
      - *Calanopia americana*
      - *Labidocera acutifrons*
      - *Labidocera* sp.
      - *Pontella spinipes*
      - *Pontella pennata*
      - *Pontellopsis villosa*
    - Harpacticoida
      - *Macrosetella gracilis*

Table 18. (Continued)

    - Cyclopoida
      - *Corycaeus* sp.
      - *Oncaea* sp.
      - *Oithoina* sp.
      - *Sapphirina* sp.
  - Cirripedia (nauplii)
    - *Balanus* (*amphitrite* complex)
    - Species B
  - Stomatopoda (larvae)
    - *Squilla* sp.
    - *Gonodactylus* sp.
  - Mysidacea
  - Cumacea
  - Amphipoda
    - *Rhabdosoma* sp.
    - Hyperiid Species A
  - Decapoda
    - Penaeidea
      - *Penaeus* spp. larvae
      - *Solenocera* sp. larvae
      - *Lucifer faxoni*
    - Caridea
      - *Alphaeus*
    - Thalassinidea
      - *Callianassa*
    - Anomura
      - Porcellanid zoea
      - Paguridea zoea and glaucothoe
      - Hippidea zoea and megalopa
    - Brachyura (zoea and megalopa)
      - *Portunus gibbesii*

- Echinodermata
  - brachiolaria larvae
  - ophiopluteus larvae
  - auricularia larvae

- Thaliacea
  - Species A and B

- Larvacea
  - *Oikopleura* sp.
  - Species B

- Chaetognatha
  - *Sagitta enflata*
  - *Sagitta tenuis*
  - *Sagitta hispida*

Table 19. Categories of organisms counted in Buccaneer Field plankton samples.

I. Kemmerer Bottle Samples (nannoplankton)[1]

- Meroplankton
  - Porifera larvae
  - trochophore larvae

II. #20 Net Samples[2]

- Meroplankton
  - *Obelia* sp.
  - polychaete larvae
  - cyphonautes larvae
  - bipinnaria larvae
  - ophiopluteus larvae
  - echinopluteus larvae
  - auricularia larvae
  - Cirripedia nauplii
  - Cirripedia cypris
- Holoplankton
  - Larvacea

III. #6 Net Samples

- Meroplankton
  - hydromedusae (excluding *Obelia*)[3]
  - polychaete post-trochophore larvae[3]
  - stomatopod larvae[3]
  - caridean larvae[3]
  - *Callianassa* larvae[3]
  - anomuran zoea[3]
  - brachyuran zoea[2]
- Holoplankton
  - ostracods[2]
  - calanoid copepods[2]
  - hyperiid amphipods[3]
  - chaetognaths[3]

---

[1] subsample counted in Palmer-Maloney cell at 200X.

[2] subsample counted in Ward zooplankton counting wheel at 30X.

[3] counted from subsample representing at least 1/32 of sample.

Table 20. Mean densities of holoplankton from #6 (243 µm mesh) net tows at Buccaneer Field.

Date	Platform A	Jacket C	Control
May 24 (day)	817.10 ± 45.65 [1]		
June 3 (day)	874.83 ± 173.15	487.59 ± 53.51	847.78 ± 33.06
June 22 (day)	1073.45 ± 227.30	1287.49 ± 99.78	1343.50 ± 97.87
August 10 (day)	25.91 ± 1.49	157.43 ± 33.23	10.73 ± 2.09
October 1 (night)	904.10 ± 43.70	1925.60 ± 26.05	1221.06 ± 48.00
October 2 (day)	270.56 ± 26.34	265.18 ± 11.42	418.07 ± 31.54
November 2 (night)	1615.05 ± 81.01	1677.37 ± 173.56	1012.98 ± 37.66
November 2 (day)	578.51 ± 27.69	230.69 ± 24.28	530.11 ± 29.96
December 9 (night)	2724.86 ± 220.89	2446.53 ± 193.68	1675.58 ± 94.62
December 9 (day)	1833.68 ± 520.17	2156.78 ± 139.91	104.48 ± 15.26

[1] mean ± 1 standard error based on five replicates. Units are individuals m^{-3}.

Table 21. Mean densities of meroplankton from #6 (243 μm mesh) net tows at Buccaneer Field.

Date	Platform A	Jacket C	Control
May 24 (day)	67.60 ± 7.68 [1]		
June 3 (day)	11.85 ± 3.36	22.70 ± 11.86	68.91 ± 13.23
June 22 (day)	17.94 ± 2.53	45.07 ± 9.07	20.90 ± 2.43
August 10 (day)	147.76 ± 26.30	14.23 ± 1.15	42.46 ± 11.51
October 1 (night)	74.43 ± 19.01	38.95 ± 9.06	76.62 ± 5.93
October 2 (day)	558.63 ± 156.89	89.44 ± 18.88	80.07 ± 35.44
November 2 (night)	61.59 ± 16.04	251.57 ± 61.20	31.47 ± 1.93
November 2 (day)	20.33 ± 3.09	15.38 ± 2.57	25.18 ± 3.30
December 9 (night)	4.78 ± 1.39	14.47 ± 1.32	619.49 ± 1.31
December 9 (day)	.30 ± .00	3.49 ± .68	.51 ± .01

[1] mean ± 1 standard error based on five replicates. Units are individuals m^{-3}.

Table 22. Mean densities of holoplankton from #20 (80 μm mesh) net tows at Buccaneer Field.

Date	Platform A	Jacket C	Control
May 24 (day)			
June 3 (day)	3670.30 ± 640.35 [1]	4174.15 ± 630.28	1629.03 ± 269.74
June 22 (day)	3545.34 ± 729.21	2114.95 ± 316.18	3333.00 ± 686.58
August 10 (day)	266.16 ± 47.29	566.41 ± 136.44	613.58 ± 106.01
October 1 (night)	2008.30 ± 110.70	1423.76 ± 249.92	1666.84 ± 114.86
October 2 (day)	7671.38 ± 1892.40	7576.88 ± 662.52	1315.54 ± 57.29
November 2 (night)	50.57 ± 16.55	96.37 ± 19.61	201.13 ± 26.83
November 2 (day)	77.90 ± 14.01	39.37 ± 19.27	228.73 ± 16.18
December 9 (night)	776.05 ± 129.52	201.26 ± 16.71	619.49 ± 85.14
December 9 (day)	633.82 ± 67.84	178.25 ± 7.65	441.97 ± 140.11

[1] mean ± 1 standard error based on five replicates. Units are individuals m^{-3}.

Table 23. Mean densities of meroplankton from #20 (80 μm mesh) net tows from Buccaneer Field.

Date	Platform A	Jacket C	Control
May 24 (day)	1302.20 ± 257.10 [1]		
June 3 (day)	886.33 ± 106.68	1454.65 ± 102.26	185.36 ± .47.81
June 22 (day)	938.46 ± 358.05	306.86 ± 42.68	942.04 ± 182.21
August 10 (day)	41.20 ± 7.24	19.26 ± 6.09	28.62 ± 4.54
October 1 (night)	268.15 ± 30.04	1658.90 ± 333.25	423.04 ± 20.46
October 2 (day)	40.50 ± 11.15	37.49 ± 18.88	12.24 ± 3.77
November 2 (night)	13[illegible].56 ± 45.70	185.16 ± 17.58	151.83 ± 11.93
November 2 (day)	[illegible]22.12 ± 49.57	418.39 ± 96.39	41.32 ± 8.66
December 9 (night)	3354.39 ± 587.23	861.45 ± 142.69	428.67 ± 60.97
December 9 (day)	276.80 ± 144.48	910.58 ± 49.45	27.60 ± 7.59

[1] mean ± 1 standard error based on five replicates. Units are individuals m^{-3}.

Table 24. Densities of meroplankton in Kemmerer water samples from Buccaneer Field.

Date	Platform A		Jacket C		Control	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.
May 24 (day)	7.35	2.03				
June 3 (day)	7.89	.67	6.78	2.06	8.56	2.16
June 22 (day)	9.89	.71	7.33	.73	4.00	.90
October 1 (night)	7.44	3.07	7.08	3.35	5.73	1.63
November 2 (day)	12.89	2.30	11.11	2.96	10.22	3.51
December 9 (day)	5.78	2.08	6.00	1.31	5.45	2.43

[1] mean of ten replicates in 10^5 individuals per m^3; [2] standard error

Table 25. Proportions of meroplankton in pooled #6 and #20 Buccaneer Field plankton samples.

	Platform A		Jacket C		Control	
	$\bar{x}$[1]	s.e.[2]	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Date						
May 24 (day)	.5542	.0442				
June 3 (day)	.1716	.0192	.2452	.0209	.0884	.0124
June 22 (day)	.1556	.0261	.0928	.0067	.1672	.0140
August 10 (day)	.4035	.0491	.0468	.0068	.0997	.0098
October 1 (night)	.1048	.0040	.3276	.0256	.1477	.0057
October 2 (day)	.0830	.0244	.0152	.0023	.0492	.0170
November 2 (night)	.1030	.0254	.1958	.0060	.1318	.0095
November 2 (day)	.1674	.0472	.5800	.0721	.0803	.0119
December 9 (night)	.4762	.0296	.2458	.0295	.1595	.0162
December 9 (day)	.0875	.0395	.2904	.0258	.0528	.0058

[1] mean of five replicates; [2] standard error

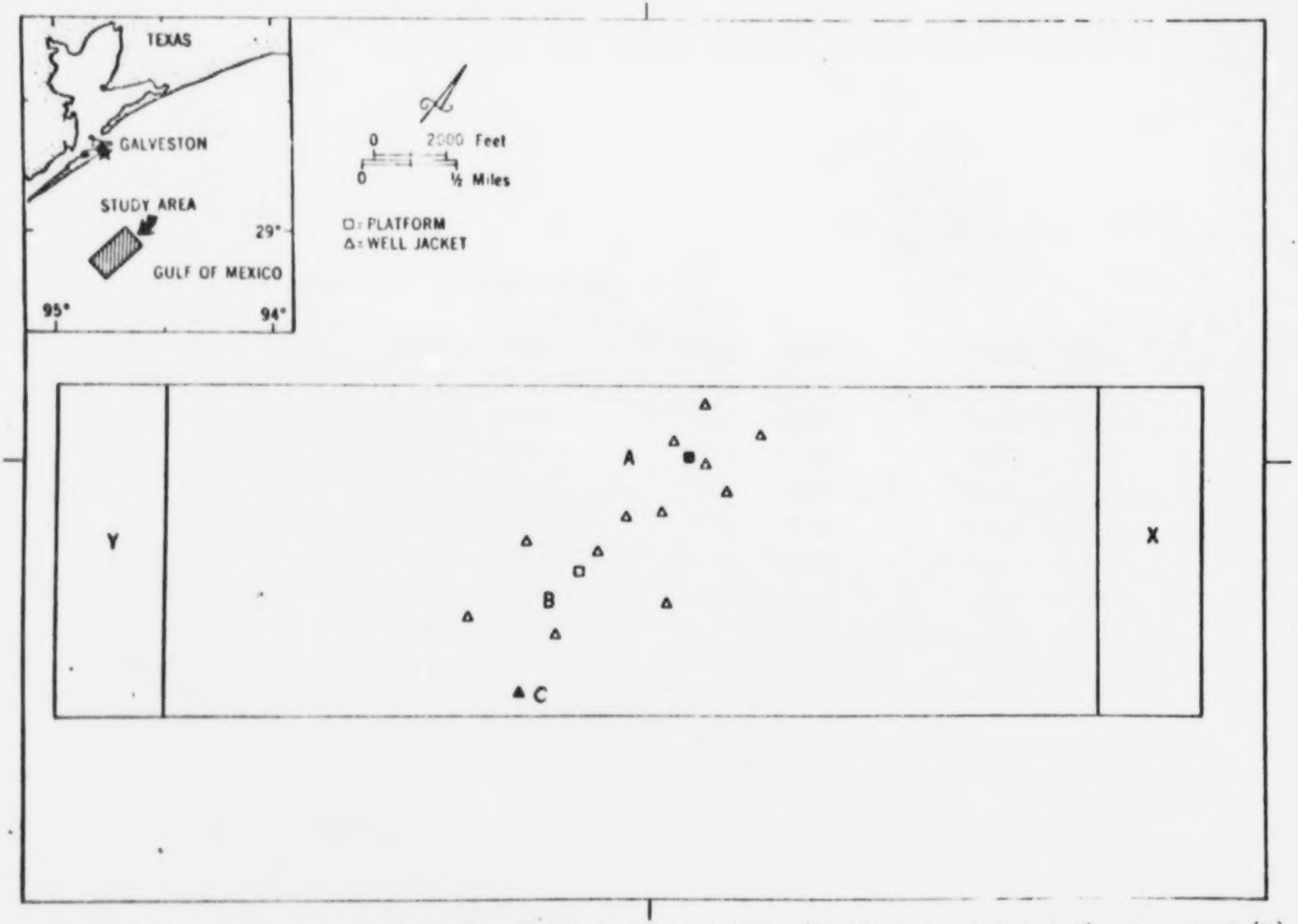
TEXAS
GALVESTON
STUDY AREA
GULF OF MEXICO
29°
95°
94°
0
2000 Feet
0
½ Miles
□: PLATFORM
Δ: WELL JACKET
A
B
C
X
Y

Figure 1. Locations of Buccaneer Field sampling stations (Platform A and Jacket C) and control (X)

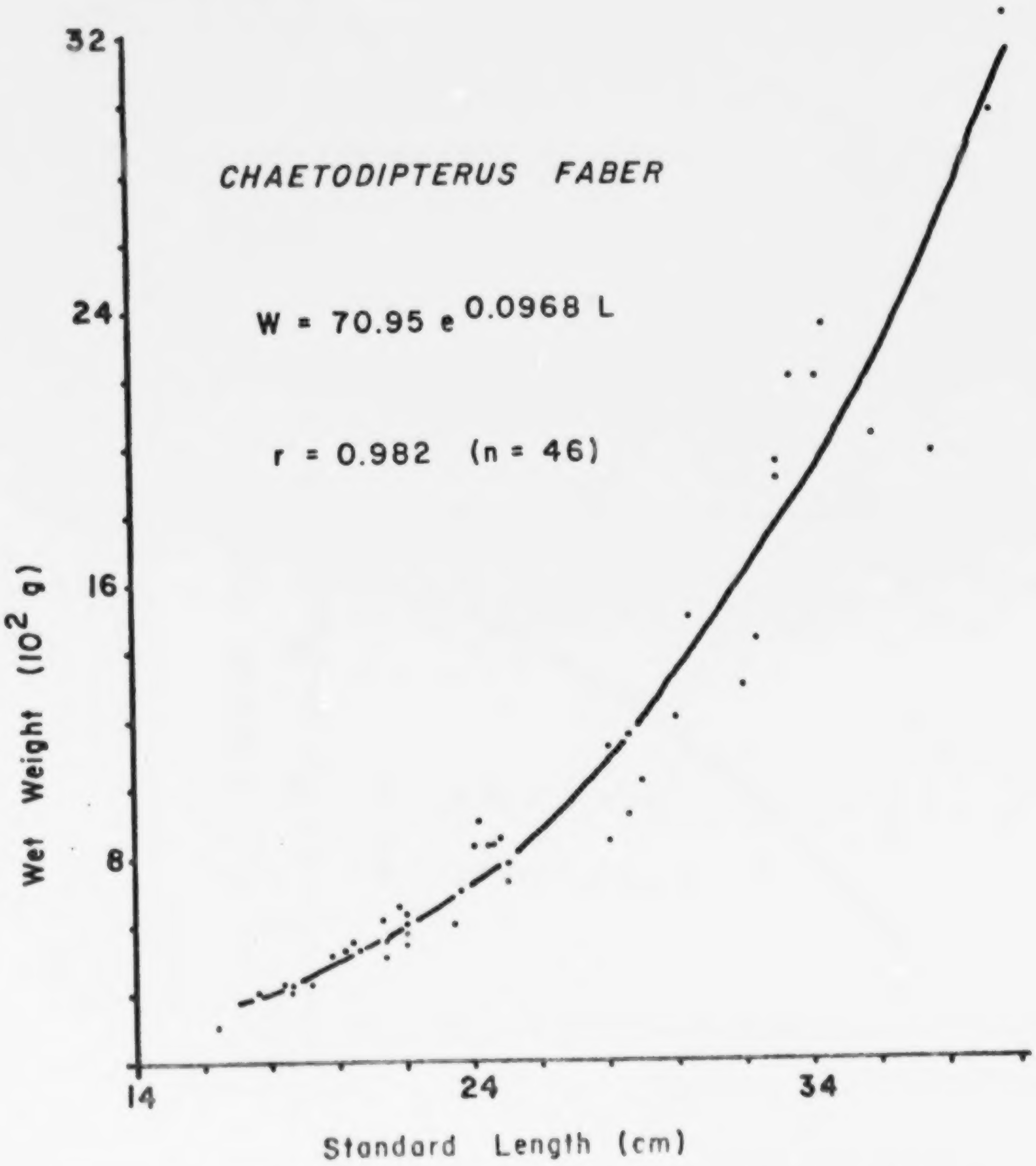

Figure 2. Length-weight relationship for *Chaetodipterus faber*.

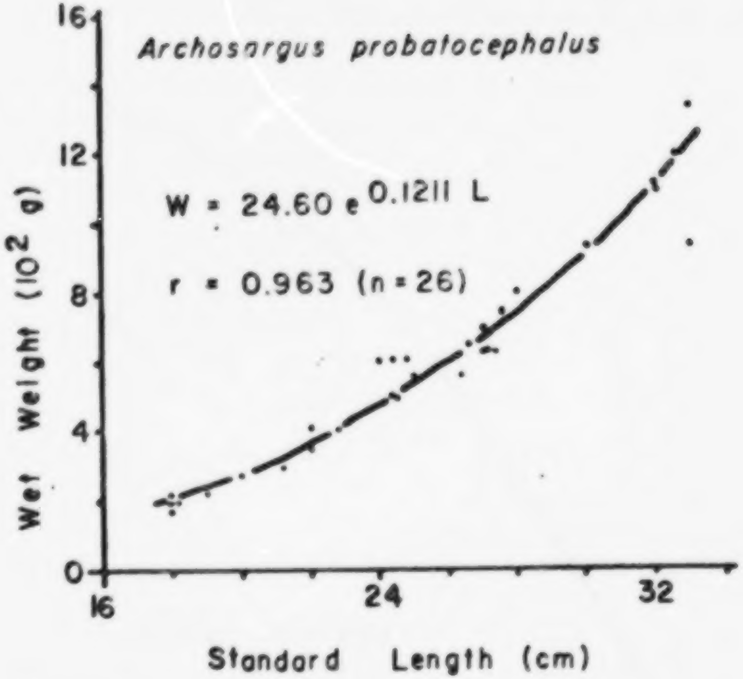

Figure 3. Length-weight relationship for *Archosargus probatocephalus*.

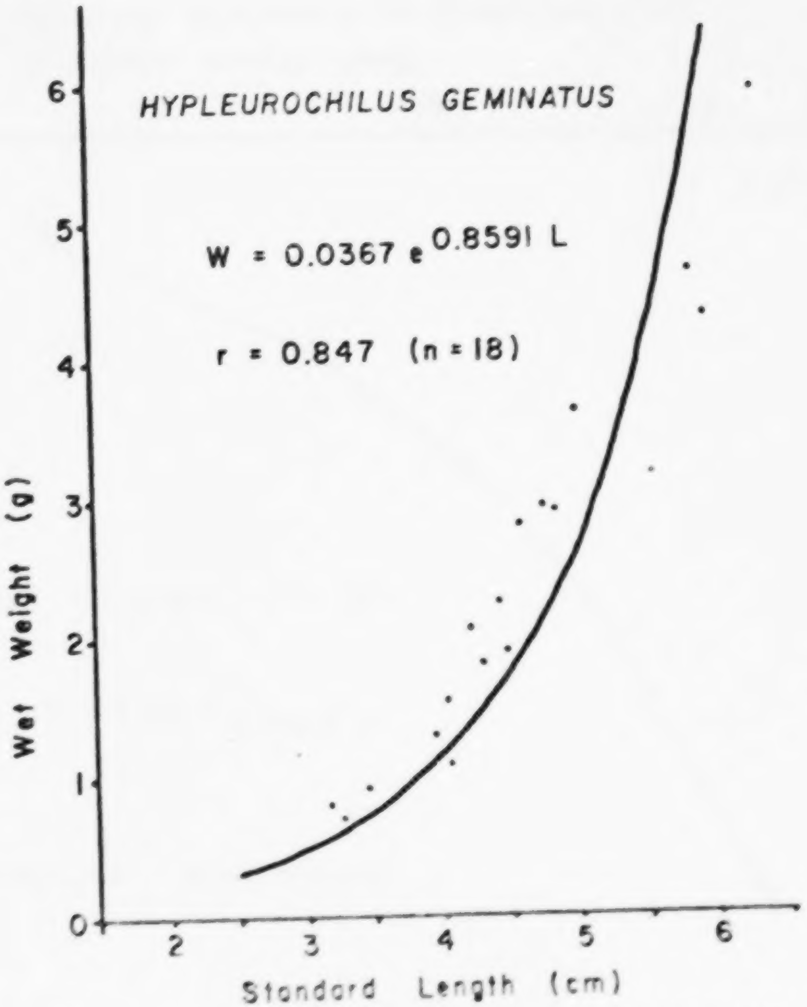

Figure 4. Length-weight relationship for *Hypleurochilus geminatus*.

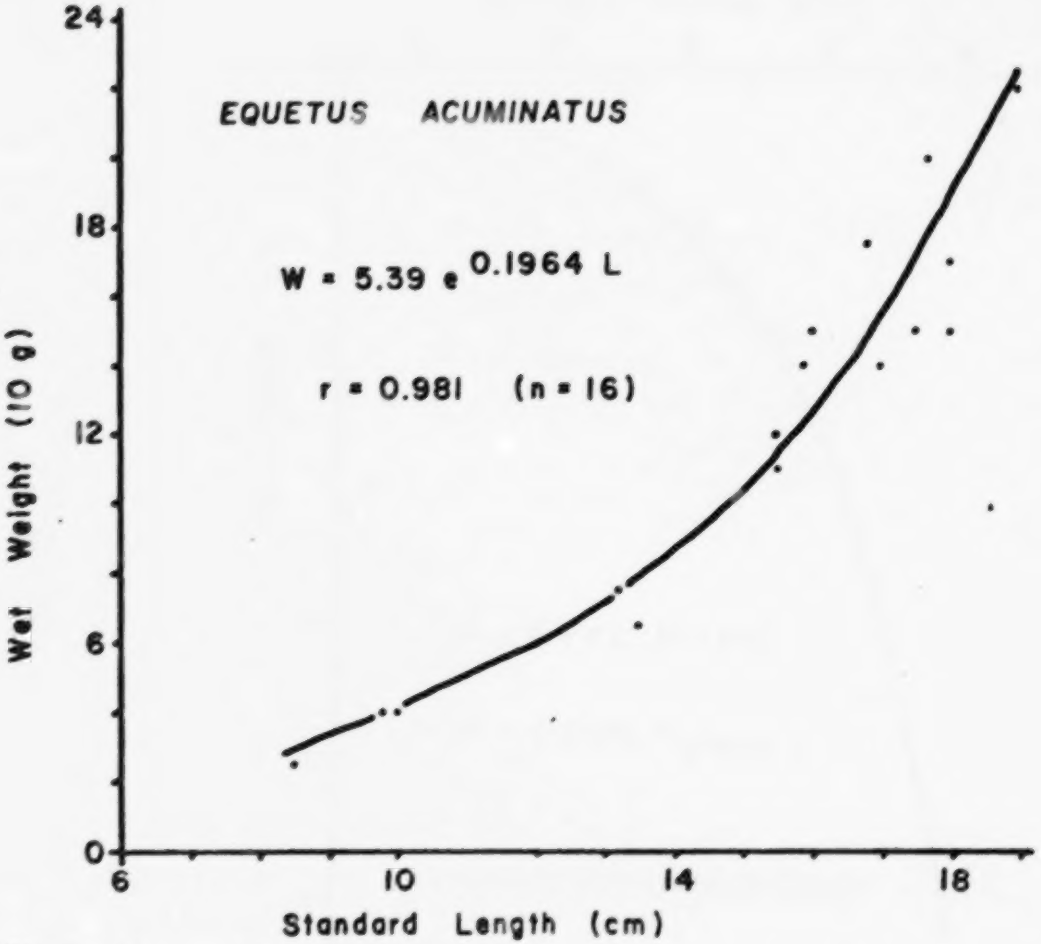

Figure 5. Length-weight relationship for *Equetus acuminatus*.

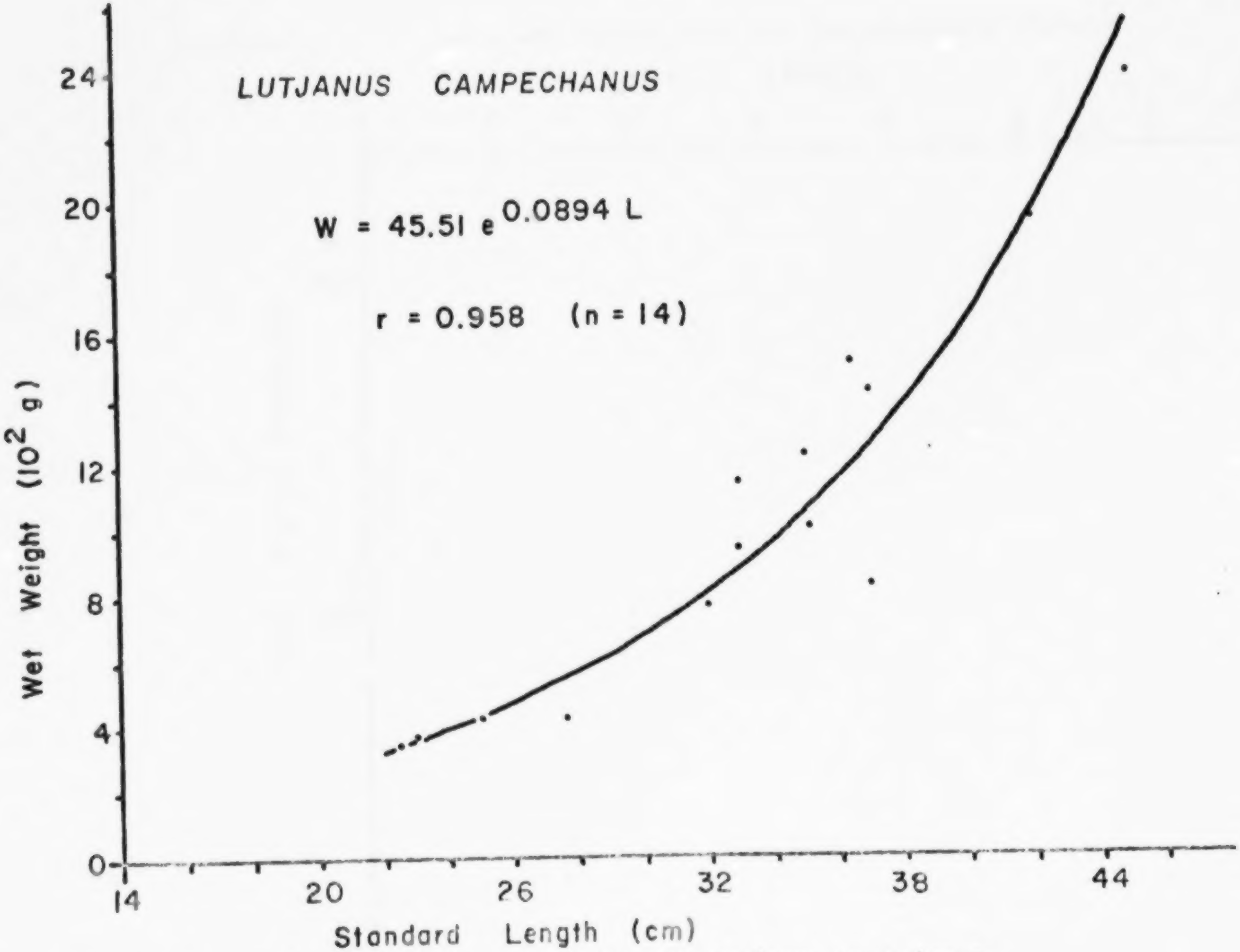

Figure 6. Length-weight relationship for *Lutjanus campechanus*.

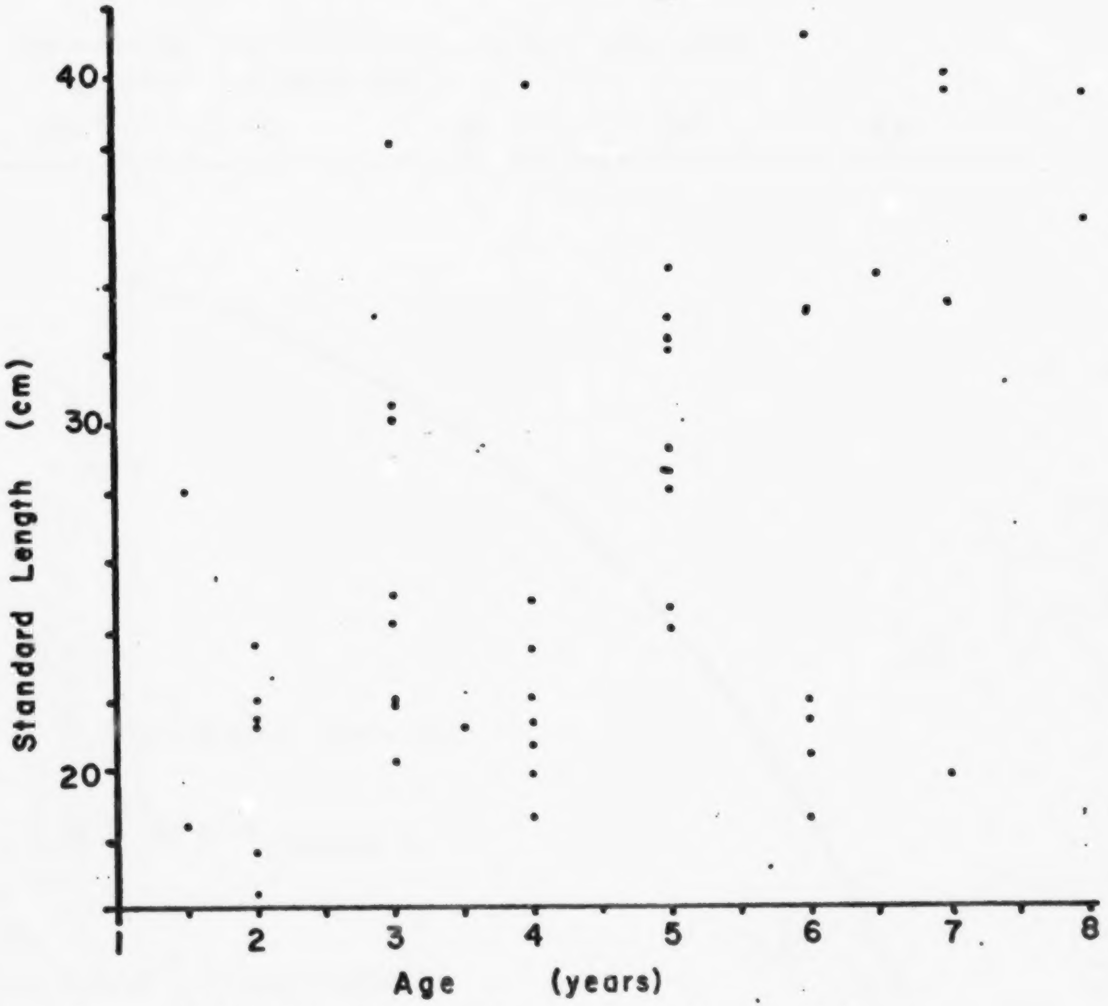

Figure 7. Length-age relationship for *Chaetodipterus faber*.

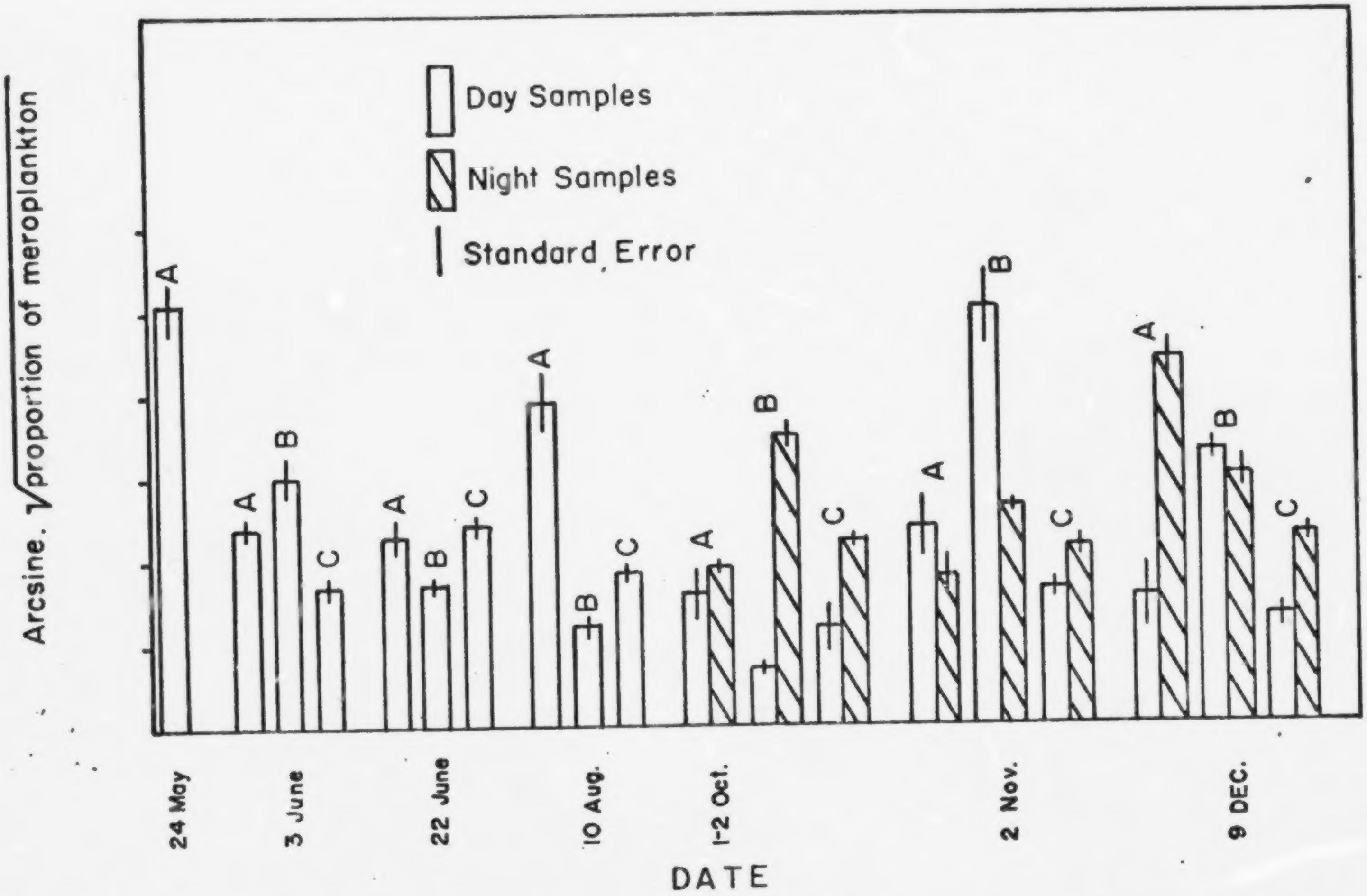

Figure 8. Proportions of meroplankton in Buccaneer Field plankton tows.

THE EFFECT OF STRUCTURES ON MIGRATORY AND LOCAL MARINE BIRDS

Principal Investigator

Glenn D. Aumann

EXECUTIVE SUMMARY

A total of 87 species and 3,911 individuals birds were identified and counted during the four quarters of this study. One species, the black tern, accounted for 1,996 (51%) of the total number of individuals. Migratory land birds accounted for 459 (12%) of the total number of individuals but represented 75 (86%) of the 87 species identified. The remainder of the species and individuals were seasonal residents of the general area. A total of 71 dead birds were found on the platform. All were members of the migratory land bird group. On the basis of one year's data it is reasonable to conclude that the effect of structure on migratory marine birds is negligible. The effect on resident marine birds is beneficial in providing food and resting areas. The effect on migratory land birds is possibly detrimental, but will require further study to warrant definite conclusions.

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INTRODUCTION

The Buccaneer Oil Field structures represent one of many man-made changes in the waters of the Northwestern Gulf of Mexico. This area comprises a well-known and long-used flyway for migratory birds which pass from southern Mexico and the Yucatan Peninsula northward to the shores of the Gulf states in the spring and pass southward along the same route in the fall. Prior to the establishment of man-made structures in the Gulf, the migratory route would necessarily have been across a featurless expanse of water 480 nautical miles wide at the narrowest point, with the complete trip being made non-stop (Pettingill, 1970). Birds migrating across water fly at heights of approximately 150-300 meters (Bellrose, 1971). Flying at this altitude, birds can readily see structures the size of the Buccaneer Oil platforms. It has been noted that birds will land on ships and structures during the migratory season, particularly under adverse weather conditions.

The Buccaneer Field is approximately twenty-five nautical miles from nearest landfall. On clear days, the structures can be seen quite readily over that distance from an elevation of one hundred meters or more. The presence of the field has resulted in increased boat traffic between shore and the field. The combination of visibility and boat traffic presumably can affect flight patterns of migratory birds and feeding habits of marine birds along the near coastline. This study was undertaken to determine the effects, if any, on migratory birds passing through in the spring and fall, and to determine the effects of the structures on feeding habits of resident marine birds.

MATERIALS AND METHODS

An annual schedule of observation periods was established to coincide with spring and fall migration periods and with summer and winter resident birds. Observations were conducted from Platform A within the Buccaneer Field on four days of each quarter and from boat deck in a control area five to seven nautical miles west of the Field on two days of each quarter. Observations were made with the aid of binoculars within approximately 500 meters of the platform and the boat used in the control area. A Field Guide to the Birds of Texas (Peterson, 1960), Birds of North America (Robbins, 1966) and the Bird Life of Texas (Oberholser, 1974) were used as references for identification and information pertaining to habits of each species.

Data collected consists of identification to species, numbers of individuals, flight directions of those birds observed flying by, feeding activities of those marine birds foraging over the surface of the water and the behavior and condition of birds on or near the platform. The data was tabulated in four four-hour time segments, beginning at 0600 hours and ending at 2200 hours.

RESULTS

Observation periods for the four quarters have been completed. The data has been analyzed to the following extent:

Spring Quarter

Seventy-four man-hours of observation were conducted from Platform A on May 15th, 16th, 22nd and 23rd. Table 1 lists the fifty-nine species of birds noted either on or near the platform area. A total of 2,177 birds were identified and counted during the seventy-four hour observation period. One species, Chlidonias niger (black tern) accounted for 1,769 of that total. Sixty-one dead birds were found on Platform A during the observation period, representing members of twenty-seven species. One hundred and sixty-seven birds were observed on the platform for varying periods of time.

Twelve man-hours of observation were conducted in the control area during the spring quarter. No species of birds were sighted.

Summer Quarter

Seventy-five man-hours of observation were conducted from Platform A on July 10th, 11th, 24th and 25th. Table 2 lists the eight species of birds noted either on or near the platform area. A total of two hundred and sixty-one birds were identified and counted. One hundred and seventy-eight of the total were Larus atricella (laughing gull) and sixty-nine of the total were Thalasseus maximus (royal tern). Six birds were observed on the platform during the observation period, representing members of five species. No dead birds were found on the platform.

Thirty-seven man-hours of observation were conducted in the control area on July 22nd and 24th during the summer quarter. Table 3 lists the five species of birds identified. Two hundred and forty-seven individual birds were counted during the observation time. One hundred and forty-eight of the total were feeding over the surface of the water. The other ninety-nine were observed flying in various directions.

Fall Quarter

Seventy-nine man-hours of observation were conducted on Platform A on

September 4th, 5th, 11th and 12th. Table **4** lists the thirty species of birds noted either on or near the platform area. A total of one hundred and seventy-five birds were identified and counted. One hundred and ten of the total were observed on the platform for varying periods of time. Sixty-five of the total were observed flying by the platform. No dead birds were observed on the platform during the fall quarter observation period.

Thirty-three man-hours of observation were conducted in the control area on September 8th and 17th during the fall quarter. Table **5** lists the ten species of birds identified. One hundred and two individual birds were counted during the observation time. Thirty of that total were feeding over the surface of the water. Seventy-two were observed flying in various directions.

Winter Quarter

One hundred man-hours of observation were conducted from Platform A on December 18th and 19th and January 8th and 9th. Table **6** lists the fourteen species of birds noted either on or near the platform area. A total of 798 birds were identified and counted during the one hundred man-hour observation period. Two species, Larus atricilla (laughing gull) and Thalasseus maximus (royal tern) accounted respectively for 540 and 186 of the total 798 birds. Ten dead birds were found on Platform A during the observation period, representing members of five species. Seventeen birds were observed on the platform for varying periods of time.

Fourteen man-hours of observation were conducted in the control area on December 16, 1976. Table **7** lists the seven species of birds identified. One hundred and fifty-one individual birds were counted. Three species, Larus atricilla (laughing gull), Thalasseus maximum (royal tern) and Chen caerulescens (snow goose) accounted respectively for 83, 12 and 44 of the total 151 birds.

INTERPRETATION

Conclusions based on the data collected and analyzed to date must be viewed as tentative at best. The Buccaneer Oil Field structures appear to have effects on birds in both relationship to the species involved and the season of the year. Thus, the following tentative interpretations are made on a seasonal basis.

Spring Quarter

Over one hundred species of birds are known to migrate over the Gulf of Mexico along a route which includes the Buccaneer Oil Field. Approximately another one hundred species migrate over routes which lie to the east or the west of the Yucatan Peninsula-Galveston line, with occasional overlap of routes due to weather patterns or disorientation of the birds. The migratory period extends from early April for early migrants to early June for late migrants (Pettingill, 1970).

Northward migration over the Gulf in spring is initiated by change in length of day. However, the exact timing of departure from the Mexican coast is more closely regulated by frontal weather patterns. The migratory departures from Mexico are heaviest during warm fronts moving in a northerly direction and lightest or non-existant during periods of cold fronts moving in a southerly direction (Gauthreaux, 1971).

Under favorable weather conditions at the point of departure and continuing favorable across the Gulf and along the coastline, small migratory birds will make the flight non-stop until reaching some point inland as far as 25 to 75 nautical miles (Lowery, 1945). If adverse weather conditions, that is, a frontal system with northerly winds, is encountered during the last portion of the flight, birds arriving on the U.S. Gulf Coast are exhausted and will make land-fall at the earliest opportunity (Gauthreaux, 1971).

Small passerine birds have an average flight speed, time of departure from the Yucatan Peninsula and distance to travel that they arrive on the northern coast during daylight hours (Gauthreaux, 1971). Flight elevation during daylight hours has been recorded from aircraft and radar observations to be approximately 350 to 500 meters (Bellrose, 1971). Thus, on clear days, migratory birds can readily sight structures as large as the Buccaneer Oil Field.

Data collected on Platform A during the spring quarter indicates that the first observation period was conducted during a rather heavy northward flight of migrants, but the presence of birds on the platform also indicates that the several days prior to May 15th was most likely heavier. Migration near the Gulf of Mexico was considered unusual in the Spring of 1976 by several onshore observers (Smith, 1976; Webster, 1976). Northerly winds on May 13th through May 15th caused a great fallout of migrants along the coast. In the absence of such winds, migrants tend to continue inland for distances of twenty-five to one hundred miles before making landfall.

Sixty-one dead birds were recovered from the platform during the spring observation period. Of these, twenty-one died on the platform between 2200 hours on May 15th and 1700 hours on May 16th. Death appeared to result from exhaustion or lack of food and water. No birds were observed colliding with the structure or coming into contact with any substance. The mortality rate cannot be considered excessive as there are documented cases of large mortality over natural habitats during migratory periods. Smith (1976) notes that 200,000 migrants were estimated to have died over Lake Huron on a single day in late May of 1976. Most birds which landed on the platform stayed for varying periods of time ranging from several minutes to one or two hours and then flew north toward the coast. In several instances it was possible to keep track of individual birds for long periods of time. On the basis of minimal data, it appeared that any bird staying on the platform for more than six hours after arrival would eventually die there. It is assumed that exhaustion from the trans-Gulf flight and energy consumed from basal metabolism after reaching the platform caused death from starvation.

The large numbers of black terns recorded during the spring quarter were observed feeding over the water within visual range of the platform. The black tern migrates across the Gulf during May and June (Peterson, 1960) and the observation periods on May 15th and 16th were apparently during a peak migratory wave of this species. The oil field structures or associated boat activity did not seem to have any particular attraction for this species, as they were also observed over wide area of the Gulf away from the platform area. Laughing gulls, royal terns and common terns appeared to be attracted to the structures and the associated human activity. Flight directions and numbers of birds of these three species appear to be directly related to feeding activity in the vicinity of the oil field.

Observation in the control area during the spring quarter yielded no data. The first control area selected was approximately five nautical miles northeast of Platform A. Weather conditions were clear, with visibility over fifteen miles and wind speed of approximately two knots. Large birds, most likely gulls and terns, were observed at a distance of over three nautical miles, well out of the area considered for a control. Their general flight directions were between the coastline and the Buccaneer Oil Field. Adverse weather conditions and problems with scheduling ship-time prevented completion of the second observation period in the control area during the spring quarter.

Summer Quarter

The number of species observed on the platform during the summer quarter was eight, with laughing gulls and royal terns comprising 247 of the total 261 birds seen. The presence of the oil field structures and associated boat traffic can quite safely be considered to be beneficial for these two species, as most individual birds were observed either following, going toward or returning from man-made objects. The other species observed were few in number and remained on the platform for only short periods of time. They all represent summer terrestrial residents along the upper Gulf coast of Texas and possibly represent individuals which sighted the oil field structures from land and flew out.

Birds observed in the control area during the summer quarter were all local summer resident marine birds which feed over open water along the coastline. Magnificient frigatebirds were seen in the control area, but not over the oil field area. However, not a large enough sample was made to warrant conclusions that this species would avoid the man-made structures. Many of the gulls and terns observed appeared to be flying from one vessel to another as the ships passed through the general vicinity of the control area and the relatively high count of individual birds (247) can perhaps be accounted for by reason of their foraging flights.

Fall Quarter

Fall migration, like spring migration, is initiated by change in daylength. Migratory birds move southward over the central portion of the U.S. The direct flight over the Gulf of Mexico is more closely regulated by frontal patterns on the U.S. mainland. Able (1972) states that the conditions most conducive to autumnal trans-Gulf flight occur shortly after the passage of a massive cold front which penetrates far into the Gulf. A less favorable, but still conducive condition is the presence of high pressure cells over the central and eastern U.S. with airflow across the Gulf generally from the northeast or east. Weather conditions other than the above two result in bird populations building up along coastal land areas until favorable conditions for trans-Gulf migration occur. Fall migration extends from late September through mid-November, depending upon the species involved.

Observations on the platform during the fall quarter resulted in recognition of one hundred and seventy-five birds of thirty different species. No dead birds were found and all birds on the platform appeared alert and healthy. Insectivorous birds were observed feeding on moths, butterflies, small beetles and other flying insects which were in abundance on the platform. Nearly one-third of the birds were observed flying south or southwest past the platform and did not land. Approximately one-third of those which landed on the platform left within a few minutes. On the basis of data collected, it appears reasonable to speculate that the platform structures have no adverse effect on migratory birds during the fall flight. The relative proximity of the oil field to the mainland would require only an hours flight for most small birds and if they continued on their southerly flight within a short period of time it should not make a significant difference in arrival time on the northern Mexican coastline.

Winter Quarter

The number of species observed on or near Platform A during the winter quarter was fourteen and all of them consisted of winter residents along the adjacent coastline. Laughing gulls (*Larus atricilla*) and royal terns (*Thalasseus maximus*) accounted for over ninety percent of the total birds observed. These two species are closely associated with the structures and related human activity. Flights between shore and the structures were observed, but sizeable numbers of both species remained on the jackets overnight on both observation periods. Eighty-seven laughing gulls and over forty royal terns were on the jackets at nightfall on January 8th and the same number were counted at daylight on January 9th. Both species were observed feeding on wet garbage from the platforms and the tending vessels. The other species observed were few in number and remained on the platform for only short periods of time. Flight directions when leaving the platform were usually northward toward the coast.

Birds observed in the control area during the winter quarter were all winter residents along the coast. Three small flocks of snow geese (*Chen caerulescens*) passed over the control area. Laughing gulls and royal terns constituted the other two species with large numbers of individuals.

CONCLUSION

The collection and analysis of data for the four quarters of observation during 1976-77 does not warrant definite conclusions concerning the overall effects of the Buccaneer Oil Field structures on avian species. Migratory periods during Spring and Fall cover time segments of over a month each. Within those time periods, weather factors, particularly storm front winds, have an effect on when birds start their migratory flights, how long it takes to make the trans-Gulf crossing, where landfall is made and the physical condition of the individual birds at the time they reach landfall. Observation periods during the four quarters of this study were scheduled around the availability of transportation to the platform and control areas. Consequently, data collections on any given day during the migratory seasons may or may not be representative of the season in total and could vary considerably from year to year.

Analysis of the data for the summer and winter quarters (non-migratory seasons) leads to a reasonable conclusion that the effect of the structures on birds ranges from insignificant for some species to beneficial for others. Species such as the black tern and snow goose pass through the area and apparently are not influenced negatively or positively by the structures. Terrestrial passerine birds observed on the platform were all representative of winter residents along the coast. The small number of dead birds recovered during these periods were insignificant compared to the numbers which spent short periods on the structures and left again on a northerly course. The presence of the field can reasonably be considered beneficial for species such as the laughing gull, ring-billed gull, herring gull and royal tern. Laughing gulls and royal terns in particular make extensive use of the structures and surrounding water for resting and feeding areas.

It appears reasonable to speculate from the data that fall migrants suffer no adverse effects from the presence of the structures, and possibly may benefit from them. Insect feeding birds in particular foraged to a considerable extent on the diverse and ample supply of insects present on the platform during the observation periods. Physical condition of the birds appeared to be excellent and departure time from either the platform or coastal area should have little or no effect on the duration of the flight across the gulf.

The presence of large numbers of dead birds on the platform during the spring quarter could be interpreted as a detrimental effect of the oil field structures. Mortality was never observed to be a direct result of either collisions with the structures or contamination by petrochemical substances. Dead and dying birds on the platform appeared to be a result of exhaustion and lack of food and water. If the platform structures were not present, an additional hour of flight time would put the birds on land where resources were available. However, it is well known that mortality from predators and other factors on land also contribute quite heavily to mortality of Spring migrants. It should also be noted that dead birds on the platform are readily apparent, whereas dead birds on land quite often go undetected.

LITERATURE CITED

Able, K. P. 1972. Fall migration in coastal Louisiana and the evolution of migration patterns in the gulf region. Wilson Bull., 84:231-242.

Bellrose, F. C. 1971. The distribution of nocturnal migrants in the air space. Auk, 88:397-424.

Gauthreaux, S. A. 1971. A radar and direct visual study of passerine spring migration in southern Louisiana. Auk, 88:343-365.

Lowery, G. H., Jr. 1945. Trans-Gulf spring migration of birds and the coastal hiatus. Wilson Bull., 57:92-121.

Oberholser, H. C. and E. B. Kincaid, Jr. 1974. The Bird Life of Texas. U. Texas Press, Austin, Texas.

Peterson, R. T. 1960. A field guide to the birds of Texas. Houghton-Mifflin Company.

Pettingill, O. S. 1970. Ornithology in laboratory and field. Burgess Publishing Company.

Robbins, C. S., Bertel Bruun, and Herbert S. Zim. 1966. Birds of North America. Golden Press, New York.

Smith, P. W. 1976. The Changing Seasons. American Birds Vol. 30:4:805-810.

Webster, Fred. 1976. The Spring Migration: South Texas Region. American Birds Vol. 30:4:863-865.

APPENDIX

TABLE 1

PLATFORM A SPECIES LIST - SPRING QUARTER

Butorides virescens	Green heron
Bubulcus ibis	Cattle egret
Porzana carolina	Sora
Porphyrula martinica	Purple gallinule
Larus delawarensis	Ring-billed gull
Larus atricilla	Laughing gull
Sterna hirundo	Common tern
Chlidonias niger	Black tern
Coccyzus americanus	Yellow-billed cuckoo
Tyrannus tyrannus	Eastern kingbird
Muscivora forficata	Scissor-tailed flycatcher
Myiarchus crinitus	Great crested flycatcher
Empidonax sp.	Flycatcher
Contopus virens	Eastern wood pewee
Riparia riparia	Bank swallow
Hirundo rustica	Barn swallow
Petrochelidon pyrrhonota	Cliff swallow
Progne subis	Purple martin
Mimus polyglottos	Mockingbird
Dumetella carolinensis	Gray catbird
Catharus ustulatus	Swainson's thrush

TABLE 1. (Continued)

Bombycilla cedrorum	Cedar waxwing
Vireo griseus	White-eyed vireo
Vireo flavifrons	Yellow-throated vireo
Vireo olivaceus	Red-eyed vireo
Vermivora peregrina	Tennessee warbler
Vermivora celata	Orange-crowned warbler
Vermivora ruficapilla	Nashville warbler
Dendroica petechia	Yellow warbler
Dendroica magnolia	Magnolia warbler
Dendroica tigrina	Cape May warbler
Dendroica virens	Black-throated green warbler
Dendroica fusca	Blackburnian warbler
Dendroica dominica	Yellow-throated warbler
Dendroica pensylvanica	Chestnut-sided warbler
Dendroica striata	Bay-breasted warbler
Seiurus aurocapillus	Ovenbird
Seiurus noveboracensis	Northern waterthrush
Seiurus noveboracensis	Northern waterthrush
Seiurus motacilla	Louisiana waterthrush
Oporornis formosus	Kentucky warbler
Oporornis philadelphia	Mourning warbler
Wilsonia citrina	Hooded warbler
Wilsonia pusilla	Wilson's warbler
Setophaga ruticilla	American redstart

TABLE 1. (Continued)

Xanthocephalus xanthocephalus	Yellow-headed blackbird
Agelaius phoeniceus	Red-winged blackbird
Icterus spurius	Orchard Oriole
Euphagus cyanocephalus	Brewer's blackbird
Molothrus ater	Brown-headed cowbird
Pheucticus ludovicianus	Rose-breasted grosbeak
Passerina cyanea	Indigo bunting
Passerculus sandwichensis	Savannah sparrow
Chondestes grammacus	Lark sparrow
Spizella passerina	Chipping sparrow
Melospiza lincolnii	Lincoln's sparrow
Melospiza melodia	Song sparrow

TABLE 2

PLATFORM A SPECIES LIST - SUMMER QUARTER

Porphyrula martinica	Purple gallinule
Larus atricilla	Laughing gull
Sterna forsteri	Forster's tern
Thalasseus maximus	Royal tern
Zenaida macroura	Mourning dove
Contopus virens	Eastern wood pewee
Icterus spurius	Orchard oriole
Molothrus ater.	Brown-headed cowbird

TABLE 3

CONTROL AREA SPECIES LIST - SUMMER QUARTER

Fregata magnificens	Magnificent frigatebird
Larus atricilla	Laughing gull
Sterna forsteri	Forster's tern
Thalasseus maximus	Royal tern
Chlidonias niger	Black tern

TABLE 4

PLATFORM A SPECIES LIST - FALL QUARTER

Ardea herodias	Great blue heron
Bubulcus ibis	Cattle egret
Larus atricilla	Laughing gull
Sterna forsteri	Forster's tern
Thalasseus maximus	Royal tern
Chlidonias niger	Black tern
Zenaida macroura	Mourning dove
Caprimulgus carolinensis	Chuck-will's-widow
Archilochus carolinensis	Ruby-throated hummingbird
Colaptes auratus	Common flicker
Tyrannus tyrannus	Eastern kingbird
Tyrannus verticalis	Western kingbird
Empidonax sp.	Flycatcher
Hirundo rustica	Barn swallow
Lanius ludovicianus	Loggerhead shrike
Mniotilta varia	Black-and-white warbler
Vermivora ruficapilla	Nashville warbler
Dendroica petechia	Yellow warbler
Seiurus noveboracensis	Northern waterthrush
Geothlypis trichas	Common yellowthroat
Icteria virens	Yellow-breasted chat

TABLE 4. (Continued)

Wilsonia pusilla	Wilson's warbler
Wilsonia canadensis	Canada warbler
Setophaga ruticilla	American redstart
Dolichonyx oryzivorus	Bobolink
Agelaius phoeniceus	Red-winged blackbird
Icterus spurius	Orchard oriole
Icterus galbula	Northern Oriole
Molothrus ater	Brown-headed cowbird
Spiza americana	Dickcissel

TABLE 5

CONTROL AREA SPECIES LIST - FALL QUARTER

Morus bassanus	Gannet
Fregata magnificens	Magnificient frigatebird
Larus argentatus	Herring gull
Sterna forsteri	Forster's tern
Thalasseus maximus	Royal tern
Chlidonias niger	Black tern
Caprimulgus carolinensis	Chuck-will's-widow
Archilochus colubris	Ruby-throated hummingbird
Hirundo rustica	Barn swallow
Molothrus ater	Brown-headed cowbird

TABLE 6

PLATFORM A SPECIES LIST - WINTER QUARTER

Sula dactylatra	Blue-faced booby
Bubulcus ibis	Cattle egret
Stercorarius pomarinus	Pomarine jaeger
Larus argentatus	Herring gull
Larus atricilla	Laughing gull
Thalasseus maximus	Royal tern
Zenaida macroura	Mourning dove
Turdus migratorius	American robin
Bombycilla cedrorum	Cedar waxwing
Molothrus ater	Brown-headed cowbird
Dendroica coronata	Yellow-rumped warbier
Junco hyemalis	Dark-eyed junco
Zonotrichia leucophrys	White-crowned sparrow
Melospiza lincolnii	Lincoln's sparrow

TABLE 7

CONTROL AREA SPECIES LIST - WINTER QUARTER

Chen caerulescens	Snow goose
Larus argentatus	Herring gull
Larus atricilla	Laughing gull
Larus philadelphia	Bonaparte's gull
Thalasseus maximus	Royal tern
Bombycilla cedrorum	Cedar waxwing
Molothrus ater	Brown-headed cowbird

HYDROGRAPHY OF THE BUCCANEER OIL FIELD AND ADJACENT WATERS

Principal Investigator

John A. Martin

EXECUTIVE SUMMARY

Temperatures and salinities of waters in and adjacent to the Buccaneer Field area are affected by a number of factors such as air temperatures, surface winds, oceanic currents, and fresh-water inflow principally from the Galveston Bay-Trinity River Complex. Highest temperatures for both surface and bottom waters occurred during August. From August through January water temperatures decreased with lowest readings occurring in January. Seasonal variations in salinities of surface and bottom waters were generally similar throughout the Field area. Lowest salinities occurred during the spring and early summer. Salinities generally increased during late summer and fall with highest salinities for both surface and bottom waters occurring during the winter months of the year.

From July to October current patterns through the Buccaneer Field area showed a distinct shift in current direction from southeast offshore to southwest downshore. August and September appear to be the transitional period from easterly offshore movement to westerly downshore movement. During the late fall and winter months of the year, currents reflect a net downshore movement to the southwest.

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INTRODUCTION

The Buccaneer Oil Field Project is part of a federally funded research effort to document environmental conditions before, during, and after oil and gas exploration and production. The research is being conducted in the Buccaneer Oil Field approximately 50 km offshore of Galveston, Texas.

This part of the research effort is concerned with the physical oceanographic aspects of the waters in and adjacent to the Buccaneer Field area. The objectives of this oceanographic research are: (1) to determine and describe the seasonal current patterns, including direction and velocity, and (2) to determine the general hydrography of the oil field and adjacent waters (including temperature and salinity regimes) to provide environmental baseline data for the area.

MATERIALS AND METHODS

For the present study the hydrography of the Buccaneer Field area and adjacent waters is confined to current and temperature/salinity regimes. Analyses have been made of both surface and subsurface current movements and of temperature/salinity readings taken at surface and bottom.

Current Studies

Surface Currents--Surface currents were measured by the net movement of ballasted drift bottles. The bottles used are made of clear glass, about 22 cm in height, 6 cm in diameter, and have a capacity of 7 fluid ounces. Each bottle contains a bright reddish-orange card with a brief message in English and Spanish. A reward of 50 cents is paid for the return of the card with information on location and date of recovery. All bottles released are ballasted and float at or just under the surface.

From May 1976 to February 1977 a total of 17 hydrographic cruises were conducted in the Buccaneer Field area and adjacent waters. Except for Cruise 002-76 (June 1976) and Cruise 013-76 (November 1976) at least 90 bottles were released during each month. Usually from 6 to 20 bottles were released at each station depending upon the number of bottles available and the number of stations to be occupied during each cruise. Station locations and cruise dates can be seen in Tables 1 and 2, respectively. During Cruises 001-76, 009-76, 014-76, and 003-77 hydrographic work was completed in conjunction with ichthyoplankton sampling accomplished both around and away from the Field area. Sampling patterns during these cruises consisted of occupying stations out to approximately 100 m in depth (Figure 1).

The technique used to depict surface currents was the same as used by Day (1958). Recovered bottles were grouped into two time periods of 15 days each, i.e., 0-15 and 16-30 days. Bottles recovered after more than 30 days out were not considered. Each bottle was considered separately and plotted as a straight line connecting the points of release and recovery. Bottles in the 0- to 15-day group were plotted as a solid line, and were the only ones considered in determining rates of drift, reported in kilometers per day. Bottles out 16-30 days were plotted as dashed straight lines. The reason for the selected groupings and the exclusion of bottles recovered after 30 days is the existence of the sandy beaches throughout the northwestern Gulf of Mexico, and the possibility of bottles drifting ashore and remaining intact, not being found until some later date. The drift bottle data considered herein have been analyzed to illustrate monthly conditions from May 1976 to February 1977, and are directly applicable to determining the movement of surface oil when and if an oil spill occurs.

All drift bottle releases and recoveries are listed in Table 6.

Subsurface Currents--Subsurface current movements in the Buccaneer Field area were tracked and measured in the months of July 1976 to February 1977 (excluding December). A direction-finding system capable of tracking the drift of drogue buoys was used in this work. The Seasonde Buoy, produced by the Electro-Physics Laboratories of Columbia, Maryland, is a light-weight, free-drifting buoy employing an adjustable-depth "current trap" or sea anchor to impart to it the motion of the ocean currents in which it is immersed. The buoy continuously transmits a low-powered radio signal which is received at two or more radio receivers located at separate positions along the beach. These receivers detect the source of the radiated ground wave with loop antennas equipped with high gain preamplifiers and 360° resolvers mounted directly above the receiver. A fix on the buoy is achieved by crossing lines of bearing which determine the buoy's location relative to each of the shore stations (Parker, 1976).

Bearings to the buoys from the shore stations were obtained in the following manner. An operator located at each station took a set of bearings on each buoy at a pre-determined time so that time-of-measurement dispersion could be minimized. These bearings were determined by swinging the loop antenna in a clockwise direction until the signal could no longer be heard and noting the bearing on the resolver. The loop was then swung in a counter-clockwise direction again noting the bearing as the signal disappeared. This procedure was repeated six times and the average of both the left and right side bearings was calculated. These two values were again averaged to obtain a bearing to the buoy. If any of the individual bearings (clockwise and counter-clockwise pairs) differed by more than 5 degrees, that bearing was disregarded and a new one was taken immediately. These procedures conform to the directions given in the instruction manual for the Sea Sonde Direction Finder Set (Anonymous, 1976).

Shore receiving stations were chosen so there would be a minimum of natural or man-made interference to distort or disrupt signals between the buoys and receivers. The stations were located far enough apart so that the distance between the stations approximated the distance from each station to the released buoy. This was variable and depended upon the location of release station and movement of the buoy after release. Shore stations were moved up or down the coastline depending upon resultant current flow affecting buoy movement.

From July 1976 to February 1977 a total of 36 buoys were released on eight separate cruises. Table 3 shows the following information for each buoy: cruise number, buoy number, release date, release station, depth of current measured, days tracked, and resultant drift. Except for Cruises 005-76, 007-76, and 013-76, both surface and subsurface currents were measured. Current traps on buoys released during Cruises 005-76, 007-76, and 013-76 were set at 10 m only. During the remaining five cruises, traps were set to respond to both surface and subsurface currents. For comparison subsurface current traps for Cruises 010-76, 011-76, and 012-76 were set at 10.0, 13.7, and 18.3 m depending on the water depth at the release station. Resultant drift for each buoy was analyzed on the basis of direction and speed. Direction of buoy movement was measured from point of release directly to final position before loss of contact with the buoy. Speed of buoy movement was calculated by dividing the resultant distance traveled from point of release to final position by the number of hours the buoy was tracked.

Station locations for transponding buoy releases can be seen in Figure 2. Each buoy's daily position is signified by a symbol to distinguish it from other buoys, and after each symbol is a number signifying days out after release. Resultant movement between positions is plotted as a solid line. The transponding buoy data considered have been analyzed to illustrate monthly surface and subsurface currents from July 1976 to February 1977 in the Buccaneer Field area. The data are applicable to determining the movement of solid wastes and surface oil slicks in offshore production areas.

Temperature/Salinity Data

Temperature and salinity data were not recorded on all 17 cruises into the Buccaneer Field area. Observations and recordings of temperatures and salinities were made at seven stations in the field area ranging from

16.1 km northwest and southeast of the Field to 8.1 km northeast and southwest of the field. The pattern of these stations (H-1 - H-7) can be seen in Figure 1. Station H-3 is located at the approximate mid-point of the Field area. Table 4 lists the cruises and dates during which each of the seven stations was occupied. Temperatures and salinities for surface and bottom water samples are also listed.

Temperatures--Temperatures were measured with the Expendable Bathythermograph System R-603 (XBT) when power was available aboard ship. The Bathythermograph System automatically obtains and records ocean temperature/depth profiles. The system consists of expendable, temperature-sensing bathythermographs (XBT's), a hand-held launcher for deploying the bathythermographs, and a strip-chart recorder for recording and displaying the temperature/depth profile. Surface bucket temperatures were taken for comparison purposes with stem thermometers graduated to 0.1°C. When power was not available to operate the XBT, Nansen casts were made to obtain surface and bottom water samples so temperatures of each sample could be recorded.

Salinities--Salinities of surface and bottom water samples taken by Nansen casts were determined by the Goldberg T/C Hand-held Refractometer. The refractometer is designed for rapid, accurate reading of total dissolved solids in aqueous solutions. The salinity scale on the refractometer can be read to an accuracy of 0.1°/oo. During Cruises 008-76, 009-76, 012-76, and 013-76, conductivity readings were also determined by the Hydrolab Model TC-2 Conductivity-Temperature Meter. The meter recorded conductivity readings in micromhos per centimeter as a sensing probe was lowered through the water column down to the bottom. At 3-m increments conductivity readings were taken and later converted to salinity values (°/oo) from a conductivity-to-salinity conversion graph furnished by the manufacturer.

Unfortunately a comparison between salinities at surface and bottom taken by both instruments showed that the salinity readings determined from the conductivity meter were at times as much as 1.6°/oo lower than the refractometer salinities of duplicate water samples. In each case the refractometer was calibrated with Standard Copenhagen Water (34°/oo) prior to use. The conductivity meter was considered unreliable for data acquisition, and was not used on any cruise after Cruise 013-76 in November.

RESULTS AND INTERPRETATION

Current Studies

Surface Currents--Over the 4-month period from May to August 1976 surface current patterns indicated a dominant downshore movement from east to west. For the 5-month period from September 1976 to January 1977 no bottles released during cruises in these months were recovered within 30 days. Of 417 bottles released during cruises in these months only 18 were recovered at all. This could indicate either a stronger along- or offshore movement of surface waters or a reduction in the number of beachcombers in the fall and winter months of the year. February recoveries within 30 days indicate a predominant movement of surface waters downshore to the west. Each month's drift bottle data is considered separately both in text and illustration. A breakdown by cruise of bottles released and recovered within 0-15, 16-30 and 30 days is shown in Table 5.

May 1976--Resultant surface current patterns shown by the drift of bottles released in May 1976 are seen in Figure 3. Bottle movements indicated a predominant downshore drift to the west. Three bottles though released at station H-12, 22 km south of Freeport, moved onshore and to the northeast. This would tend to indicate either a shifting in the dominant westerly current or the existence of a nearshore countercurrent.

Current velocities of the dominant westerly surface flow averaged 12 km/day and were based on the return of two bottles released at station H-18 and recovered within 15 days near Port Aransas. The nearshore "countercurrent" averaged 6 km/day.

June 1976--Only 12 bottles were released at two stations (H-5 and H-6) during Cruise 002-76 in June. The drift patterns of the two bottles recovered indicated a dominant surface current flow initially onshore and to the west as shown by the solid line in Figure 4. Though the recovery data is minimal, there appears to be a shift or fluctutation of the current toward the north more than 15 days after bottle release.

Current velocity from the one bottle recovered within 15 days was 5 km/day.

July 1976--Figure 5 shows the drift pattern of bottles released during five separate cruises in July (Cruises 003-76 - 007-76). Of the 115 bottles released in and around the Buccaneer Field area, 18 were recovered within 30 days (Table 5). Twelve of these 18 bottles were recovered within 15 days giving an indication of a predominant onshore drift to the west and northwest. Bottles released at station H-6, 8.1 km southwest of the Field area, moved further downshore at a faster rate than did bottles released north of the Field area toward shore. Several bottles recovered more than 15 days after release moved in a north and northeasterly direction toward the Louisiana coast.

Current velocities varied throughout the study area with values averaging 17 km/day near the Field area to 4 km/day north of the Field area toward shore.

The data discussed herein for July drift patterns tend to indicate two current regimes in operation. One is the stronger downshore drift to the west. Its effect is noted further offshore. The other is a weaker, more onshore current which affects current patterns closer to shore. It appears that this weaker current may fluctuate and become an onshore counter-current to the north and northeast.

August 1976--The drift pattern of bottles released during three separate cruises in August (Cruises 008-76 - 010-76) is shown in Figure 6. There were 159 bottles released during this month both around the Buccaneer Field area and at stations out to 90 m in depth during an ichthyoplankton cruise. A total of 39 bottles was recovered within 30 days (Table 5). Twenty-one of these were picked up within 15 days of release. Predominant drift patterns indicated a strong downshore movement to the west and southwest. Bottles released from stations close to shore reflected some movement directly onshore. There was no indication of surface drift to the north or northeast.

Current velocities varied throughout the study area with values ranging from 2 km/day for the onshore current to 18 km/day for the dominant downshore current.

Analysis of current patterns in July and August indicates a transitional period in August. Nearshore surface currents, rather than moving to the north and east, had shifted back toward the west.

September-October 1976--Figures 7 and 8 show stations where bottles were released during two cruises in September and October (Cruises 011-76 - 012-76). Although 191 bottles were released during these months, only four have since been recovered (three in September and one in October). The three bottles recovered from the September releases were found on South Padre Island. Only one of these was recovered within a reasonable amount of time (39 days). It was found approximately 16.1 km north of Port Isabel. The one bottle recovered from the October releases was found on the beach at Paraiso in the state of Tabasco, Mexico. It was recovered 58 days after its release (Table 6). Due to a lack of bottle returns no analysis can be made of surface current patterns during these cruises. As shown by the Paraiso return the absence of recoveries may indicate either an along- or offshore movement of surface waters.

Historically, the release and recovery of drift bottles in September and October indicates a general west to southwesterly flow down the coast (Temple and Martin, in press).

November-December 1976--Figures 9 and 10 show stations where bottles were released during the November and December cruises (Cruises 013-76 - 014-76). Because of engine problems only one station was occupied during Cruise 013-76. Of the 15 bottles released at station H-1, none have been recovered. There were 111 bottles released during Cruise 014-76 around the Field area and at stations out to 90 m in depth during the quarterly ichthyoplankton sampling. Only one bottle has since been recovered and it was found 121 days after release approximately 8.3 km south of Port Aransas (Table 6). This bottle probably laid on the beach for some time before it was found.

January 1977--Figure 11 shows the stations where 100 drift bottles were released during Cruise 001-77 on January 17-18. There were no recoveries within 30 days, but 13 bottles were recovered between 43 and 67 days after release (Table 6). These recoveries ranged from the vicinity of the Port Mansfield jetties on South Padre Island down to Boca de Catán en Laguna Madre approximately 107 km south of Brownsville. This recovery pattern indicates an along-or offshore current movement down the coast.

February 1977--The drift pattern of bottles released during Cruise 003-77 during February is shown in Figure 12. There were 60 bottles released at the various stations. A total of 17 bottles were recovered within 30 days (Table 5). Only two of these were picked up within 15 days of release. They were released at station H-1 and recovered between Surfside Beach and San Luis Pass. Bottles released at stations further offshore apparently drifted in a southwesterly direction downshore. All of the bottles recovered between 16-30 days were found south of Port Aransas along Padre Island. Predominant drift patterns indicate a strong downshore movement to the west and southwest, a fact consistent with historical data (Temple and Martin, in press).

Current velocities from the two bottles recovered within 15 days averaged 8 km/day.

Subsurface Currents--From July to October 1976 subsurface current patterns through the Buccaneer Field area and adjacent waters showed a distinct shift in current direction from southeast offshore to southwest downshore. For the remaining months (November 1976-February 1977) subsurface current patterns indicated resultant movement downshore to the southwest. With the exception of July and December, each month's transponding buoy data is considered separately both in text and illustration. In July two fields of buoys were released on separate cruises (Cruises 005-76 and 007-76). Since the results from each set of releases are basically identical, the data are considered together in the text. No transponding buoys were released in December.

July 1976--Resultant 10-m current patterns shown by the drift of eight transponding buoys released in July 1976 are seen in Figures 13 and 14. During Cruise 005-76 five buoys were released at stations H-2 - H-4 and S-4 - S-5. Figure 13 depicts the current patterns of buoys released on this cruise. With the exception of buoy 197, all buoys were tracked for at least 3 days. The resultant drift of buoys 198-201 was 107° at .3 k (Table 3). After release each buoy initially moved in a westerly direction before being affected by the dominant easterly current. Other than being the possible results of daily fluctuations in direction and speed, it is not known what caused this seeming divergent current movement.

Three more buoys were released on July 27 during Cruise 007-76. Daily movement of each buoy is seen in Figure 14. Although buoy 206 was tracked only 1 day, buoys 204 and 205 were tracked 10 and 6 days respectively. A resultant drift of 095° at .3 k compared closely with results from Cruise 005-76 (Table 3).

From the data discussed herein, subsurface currents for July have a resultant easterly component that becomes more erratic in direction and speed in late July. This could represent the beginning of the late summer transitional period from easterly offshore movement to westerly downshore movement.

August 1976--During Cruise 010-76 five transponding buoys were released at station H-1, H-3, and H-7. Two of the buoys, 210 and 211 were set to respond to surface current movement, while the other three were set to respond to subsurface currents at varying depths (Table 3). Figure 15 shows the daily movement of each buoy after its release.

Buoys 210 and 211 were tracked for 3 and 2 days respectively. Both moved to the northwest at an average speed of almost .3 knot. Buoy 207 was quite erratic in its drift. After 9 days its resultant movement was downshore to the southwest. The other two subsurface buoys (208 and 212) moved offshore to the south after drifting westward for the first 2 days after release.

A comparison between the resultant drift of subsurface buoys released in July and August shows a definite shift in deeper current movements from an easterly direction in July to a southerly direction in August. Current speeds appeared to slow in August averaging just over .1 k. Average speeds in July were just under .3k.

Due to the short tracking time of the surface buoys, no comparison is made between surface and subsurface current drift in August.

September 1976--Six transponding buoys were released at stations H-1, H-3, and H-7 during Cruise 011-76 on September 23. As in August, two buoys (236 and 237) were set to respond to surface current movement. The others were arrayed through the Field area at various depths (Table 3). Figure 16 shows the daily movement of each buoy after its release.

Surface currents reflected a net southwest movement downshore at an average speed of just under .2 k. Deeper currents moved basically in the same direction. Buoys 209 and 230 were tracked for 1 day with the resultant drift being westward at .5 and 1.1 k respectively. An initial speed of 1.1 k seemed rather high for buoy 230, but a data recheck verified accuracy. Buoy 228 was tracked for 7 days in a resultant onshore direction before grounding itself in the shallower waters of San Luis Pass.

Buoy 232 was tracked for 11 days and moved downshore further than any other buoy released during the cruise.

With the exception of buoys 209 and 230, buoy movement was erratic and fluctuating suggesting that even though resultant movement was downshore to the southwest, influence from earlier current patterns still existed. Disregarding the buoys tracked for 1 day, current speeds from the others averaged less than .2k.

October 1976--Resultant current patterns shown by the movement of six more buoys released during Cruise 012-76 are seen in Figure 17. Both surface and subsurface buoys were released at stations H-1, H-3, and H-7. One of the surface buoys was set to respond to currents at 3 m in depth. The three subsurface buoys again varied in their depth configuration depending on the depth of the station where the buoy was released (Table 3).

Each of the surface buoys was tracked for 9 days and resultant drift of each indicated a fairly constant downshore movement to the southwest at .2 k. Two of the subsurface buoys (226 and 223) indicated much the same type of movement in both direction and speed. Buoy 227 was tracked for 1 day in a direction of 280° toward shore at .9 k.

Results from October's drift data indicate both a similarity in surface and subsurface current patterns, and a general strengthening of the downshore drift to the southwest. Influences from late summer-early fall current patterns appear to have ceased.

November 1976--Due to engine problems only one station was occupied during Cruise 013-76 on November 11. One buoy was released at station H-1 and it was set to respond to currents at 10 m in depth. Unfortunately the buoy was tracked for only 1 day and its movement can be seen in Figure 18. For that 1-day period it moved downshore (230°) at .4 k (Table 3).

January 1977--During Cruise 001-77 six buoys were released at stations H-1, H-3, and H-7. Buoys 233, 234, and 238 were set to respond to surface current movement, while the remaining three (216, 217, 231) were set at 10 m of depth (Table 3). Each buoy's daily movement is shown in Figure 19.

All three surface buoys were tracked for considerable periods of time with buoy 233 being tracked until its signal became too weak to read. Signals from buoy 238 were lost after 6 days, but the buoy was picked up 4 days later by a crew boat at the position shown in Figure 19. Though the buoys were rather erratic in their daily movement, resultant drift was downshore from 190°-243° at .2k.

Of the three subsurface buoys only buoy 231 was tracked longer than 3 days. It was tracked for 10 days and the resultant drift was quite similar to the surface buoys. Buoys 216 and 217 were tracked for 1 and 3 days respectively and moved offshore and slightly to the east.

It may be noted that all of the buoys moved offshore or east for the first 3 days after release. A strong norther that passed through the Galveston area on January 18 evidently affected buoy movement for these days. After this time the weather settled enough to allow downshore current movements to again prevail. This southwesterly movement downshore is typical for the winter months of the year (Temple and Martin, in press).

February 1977--Figure 20 shows the current patterns of three buoys released during Cruise 002-77 on February 9. Buoy 219 was set to respond to surface currents and buoys 214, 220, and 222 were set at 10 m (Table 3).

Buoy 219 was tracked for 7 days during which time it moved downshore in a resultant direction of 226° at .3 k. In a telephone conversation with a representative of the National Weather Service in Galveston, Texas on April 11, 1977, resultant daily winds were determined for the period of time when buoy 219 was being tracked. Although the winds were recorded only at Galveston, they are a good indication of wind direction and speed offshore. For the first 2 days after release easterly winds prevailed at an average speed of 11 k. During the following 2 days winds shifted to the north at 9 k. From 5 to 7 days after release, prevailing winds switched from southwesterly to northerly and then back to a southerly direction. This could account in part for the fluctuating movement of the buoy the final 3 days of its tracking life.

Buoys 222 and 214 were tracked for 1 and 2 days respectively. Buoy 220 could not be tracked at all because its signal was too weak and erratic to read. The resultant drift of the two tracked buoys averaged 264° at .4 k.

Results from both January and February drift data indicate a similarity in surface and subsurface current patterns. The dominant downshore drift to the southwest continues but is periodically interrupted by stronger wind patterns from the north and southwest.

Temperature/Salinity Data

Temperatures and salinities of waters in and adjacent to the Buccaneer Field area are affected by a variety of factors such as air temperatures, surface winds, oceanic currents, and freshwater inflow. Most of the freshwater inflow that affects the Buccaneer Field locale comes principally from the Galveston Bay-Trinity River complex. Secondary effects from the Mississippi River discharge may be felt to a lesser degree. Temperature and salinity readings from May 1976 to February 1977 for surface and bottom waters are listed by station (H-1 - H-7) in Table 4.

Due to the comparatively small difference in depths between stations in the study area, surface and bottom water temperatures and salinities were generally similar at each station for a given cruise. Plots of temperature and salinity values averaged from stations occupied during a particular month are seen in Figure 21. Values from the two August and February cruises were plotted on the 15th day of the month. The variation symbol in Figure 21 represents the extreme values of temperatures and salinities at the stations during a given month. There was no data collected for the month of June.

Temperature Data--For Cruise 001-76 in May, all stations were occupied except H-7. Surface temperatures ranged from 25.5°C to 26.5°C. Bottom temperatures ranged from 24.5°C to 25.8°C. Highest temperatures for both surface and bottom waters occurred during the August cruises with 30.5°C and 29.2°C being the highs for surface and bottom respectively. From August through January water temperatures decreased with lowest readings occurring during the January cruise. Surface temperatures ranged from 10.2°C to 13.1°C. Bottom temperatures were either the same or slightly warmer. Temperatures again started increasing after January with February averages being 13.9°C and 13.4°C for surface and bottom respectively. Due to report deadlines March and April temperatures were not included in this paper, but historically, temperatures continue to increase and follow the same pattern as seen in Figure 21 (Temple et al, 1977).

Salinity Data--Seasonal variations in salinities of surface and bottom waters were generally similar throughout the Field area. Lowest surface salinities occurred in May and averaged 27.2°/oo. Bottom salinities for May were higher averaging 31.6°/oo. The highest salinities for the area occurred during the winter months of the year with December having the highest averaged surface salinity (35.5°/oo). The bottom salinity averaged 35.6°/oo). The highest bottom salinity occurred during February and averaged 35.8°/oo. Decreases in salinity values either in surface and/or bottom waters for the spring and early summer months of the year are probably related to the peak outflow of freshwater from local river discharges, chiefly the Galveston Bay-Trinity River complex (Temple, et al, 1977).

LITERATURE CITED

Anonymous.
1976. Instruction manual for Model DF-4 Sea Sonde Direction Finder Set, ITT Avionics Division, Electro-Physics Laboratories, Equipment Manual No. 234, 72 pp.

Day, G. G.
1958. Surface circulation in the Gulf of Maine as deduced from drift bottles. U.S. Fish Wildl. Serv., Fish. Bull. 58(141): 443-472.

Parker, C. E.
1976. Tests of the ITT Seasonde Buoy System. Unpublished Manuscript, Woods Hole Oceanographic Institution, Woods Hole, Mass., 23 pp.

Temple, R. F. and J. A. Martin.
(In press) Surface circulation in the northwestern Gulf of Mexico as deduced from drift bottles.

Temple, R. F., D. L. Harrington, J. A. Martin.
1977. Monthly temperature and salinity measurements of continental shelf waters of the northwestern Gulf of Mexico, 1963-65. NOAA Technical Report NMFS, SSRF-707, 26 pp.

APPENDIX

Table 1. Location and depth of stations occupied during cruises from May 1976 to February 1977

Stations	Depth (M)	Location	
		Latitude	Longitude
H- 1	18.3	29°00'	94°49.5'
H- 2	16.1	28°55.9'	94°45.5'
H- 3	19.2	28°52'	94°41.5'
H- 4	18.2	28°48.7'	94°38.5'
H- 5	19.5	28°55.2'	94°37.6'
H- 6	20.0	28°49'	94°46.1'
H- 7	24.0	28°44.7'	94°34.6'
H- 8	32.0	28°37.5'	94°28.0'
H- 9	40.0	28°25.8'	94°17.5'
H-10	52.0	28°14.7'	94°06.5'
H-11	73.0	28°02.5'	93°56.7'
H-12	17.0	28°44'	95°18'
H-13	28.0	28°32.5'	95°07'
H-14	37.0	28°20.7'	94°56.7'
H-15	51.0	28°09.3'	94°46'
H-16	77.0	27°57.5'	94°35.5'
H-17	19.0	28°30'	95°49'
H-18	26.0	28°18.5'	95°38'
H-19	48.0	28°07'	95°27.5'
H-20	92.0	27°54.5'	95°16'
S- 1	18.3	29°04.4'	94°40.9'
S- 2	16.8	28°59.2'	94°41.2'
S- 3	19.2	28°54.2'	94°41.5'
S- 4	20.0	28°53.5'	94°36'
S- 5	16.8	28°57.2'	94°39.7'

Table 2. Inclusive dates of and stations occupied during each cruise from May 1976 to February 1977

Stations Occupied	Cruise Number	Inclusive Dates
H-1 - H-6; H-8 - H-9; H-12 - H-15; H-17 - H-20	001-76	5/24-5/29
H-5 - H-6	002-76	6/11
S-1 - S-3	003-76	7/1-7/2
H-3; H-5 - H-7	004-76	7/7
H-2 - H-4; S-4 - S-5	005-76	7/13
H-1 - H-2; H-4	006-76	7/20
H-2 - H-4	007-76	7/27
H-3; H-5 - H-6	008-76	8/9-8/12
H-1 - H-6; H-8 - H-20	009-76	8/16-8/21
H-1; H-3; H-7	010-76	8/31-9/1
H-1 - H-7	011-76	9/23
H-1 - H-7	012-76	10/18
H-1	013-76	11/11
H-1; H-2; H-4 - H-6; H-8 - H-20	014-76	11/30-12/4
H-1 - H-5; H-7	001-77	1/17-1/18
H-1; H-3; H-7	002-77	2/9-2/10
H-1 - H-2; H-4 - H-6; H-8 - H-20	003-77	2/18-3/3

Table 3. Buoy number, date of release, station, and daily drift results of transponding buoys released during cruises from July 1976 to February 1977

CRUISE NO: 005-76

Buoy Number	Date of Release	Station	Depth of Current Measured (M)	Days Tracked	Resultant Drift	
					Direction (Mag)	Speed (Knots)
197	7-13-76	H-2	10.0	1	257°	.9
198	7-13-76	H-3	10.0	3	100°	.3
199	7-13-76	H-4	10.0	3	107°	.2
200	7-13-76	S-4	10.0	6	110°	.3
201	7-13-76	S-5	10.0	7	110°	.3
CRUISE NO.:	007-76					
204	7-27-76	H-2	10.0	10	095°	.2
205	7-27-76	H-3	10.0	6	095°	.3
206	7-27-76	H-4	10.0	1	163°	.4
CRUISE NO.:	010-76					
210	8-31-76	H-3	1.0	3	299°	.2
211	8-31-76	H-7	1.0	2	300°	.3
207	8-31-76	H-1	10.0	9	231°	.1
208	8-31-76	H-3	13.7	6	172°	.1
212	8-31-76	H-7	18.3	6	150°	.2
CRUISE NO.:	011-76					
237	9-23-76	H-3	1.0	15	250°	.1
236	9-23-76	H-7	1.0	6	278°	.2
228	9-23-76	H-1	10.0	7	279°	.1
209	9-23-76	H-3	13.7	1	263°	.5
230	9-23-76	H-7	18.3	1	283°	1.1
232	9-23-76	H-7	18.3	11	230°	.2

Table 3. (Continued)

CRUISE NO: 012-76

Buoy Number	Date of Release	Station	Depth of Current Measured (M)	Days Tracked	Resultant Drift Direction (Mag)	Resultant Drift Speed (Knots)
240	10-18-76	H-3	1.0	9	249°	.2
225	10-18-76	H-7	1.0	9	250°	.2
239	10-18-76	H-7	3.0	9	238°	.2
226	10-18-76	H-1	10.0	4	250°	.3
223	10-18-76	H-3	13.7	3	255°	.3
227	10-18-76	H-7	18.3	1	280°	.9
CRUISE NO:	013-76					
229	11-11-76	H-1	10.0	1	230°	.4
Cruise No:	001-77					
233	1-18-77	H-1	1.0	13	190°	.3
238	1-18-77	H-3	1.0	10	210°	.1
234	1-18-77	H-7	1.0	10	243°	.1
231	1-18-77	H-1	10.0	10	215°	.2
216	1-18-77	H-3	10.0	1	065°	.3
217	1-18-77	H-7	10.0	3	096°	.3
CUISE NO:	002-77					
219	2-9-77	H-1	1.0	7	226°	.3
220	2-9-77	H-1	10.0	0	Signal too weak to read	
222	2-9-77	H-3	10.0	1	270°	.4
214	2-9-77	H-7	10.0	2	258°	.4

Table 4. Temperature and salinity values of surface and bottom water samples taken at stations H-1 - H-7 on cruises from May 1976 to February 1977

STATION: H-1

DEPTH: 18.3 M.

LATITUDE: 29°00'

LONGITUDE: 94°49.5'

Cruise	Day	Month	Year	Temperature °C		Salinity °/oo	
				Depth		Depth	
				Surface	Bottom	Surface	Bottom
001-76	24	5	1976	25.5°	25.0°	27.0	30.1
009-76	16	8	1976	29.5°	29.2°	32.8	32.8
011-76	23	9	1976	27.6°	27.7°	31.4	31.7
012-76	18	10	1976	23.0°	23.0°	30.8	31.1
013-76	11	11	1976	19.0°	19.5°	31.5	34.0
014-76	4	12	1976	14.5°	15.5°	34.9	36.0
001-77	18	1	1977	10.2°	11.4°	31.5	33.0
002-77	9	2	1977	11.7°	11.6°	33.9	33.9
003-77	19	2	1977	13.5°	13.4°	31.0	36.2
STATION: H-2							
DEPTH: 16.1 M.							
LATITUDE: 28°55.9'							
LONGITUDE: 94°45.5'							
001-76	24	5	1976	26.0°	24.5°	25.0	31.0
009-76	16	8	1976	29.4°	28.5°	32.7	-
011-76	23	9	1976	27.7°	27.6°	32.1	32.3
012-76	18	10	1976	22.5°	23.0°	31.2	31.7
014-76	4	12	1976	15.0°	14.9°	36.1	36.2
001-77	18	1	1977	11.6°	11.6°	32.0	33.0
003-77	19	2	1977	13.6	13.5	35.0	36.5
STATION: H-3							
DEPTH: 19.2 M.							
LATITUDE: 28°52'							
LONGITUDE: 94°41.5'							
001-76	24	5	1976	25.5°	24.5°	25.0	31.5
004-76	7	7	1976	29.0°	28.0°	28.3	30.0

Table 4. (Continued)

STATION: H-3 (Continued)

DEPTH: 19.2 M.

LATITUDE: 28°52'

LONGITUDE: 94°41.5'

Cruise	Day	Month	Year	Temperature °C		Salinity °/oo	
				Depth		Depth	
				Surface	Bottom	Surface	Bottom
008-76	11	8	1976	29.0°	28.0°	32.1	33.6
009-76	17	8	1976	30.4°	29.0°	32.0	30.9
011-76	23	9	1976	27.9°	28.1°	32.5	32.8
012-76	18	10	1976	24.0°	24.0°	33.1	33.1
001-77	18	1	1977	12.3°	12.6°	34.0	34.0
002-77	9	2	1977	12.5°	12.5°	35.0	35.2

STATION: H-4

DEPTH: 18.2 M.

LATITUDE: 28°48.7'

LONGITUDE: 94°38.5'

Cruise	Day	Month	Year	Temperature °C Surface	Temperature °C Bottom	Salinity °/oo Surface	Salinity °/oo Bottom
001-76	24	5	1976	26.0°	24.5°	30.0	32.0
009-76	17	8	1976	29.7°	28.9°	32.8	30.7
011-76	23	9	1976	28.0°	28.4°	32.5	32.6
012-76	18	10	1976	24.0°	24.0°	33.1	33.4
014-76	4	12	1976	16.4°	16.5°	36.3	36.3
001-77	17	1	1977	13.1°	13.1°	32.2	32.0
003-77	19	2	1977	14.8°	14.4°	35.5	36.0

STATION: H-5

DEPTH: 19.5 M.

LATITUDE: 28°55.2'

LONGITUDE: 94°37.6'

Cruise	Day	Month	Year	Temperature °C Surface	Temperature °C Bottom	Salinity °/oo Surface	Salinity °/oo Bottom
001-76	25	5	1976	26.0°	25.8°	26.0	31.0
004-76	7	7	1976	29.2°	-	30.0	-
008-76	11	8	1976	29.0°	28.0°	32.1	32.8
009-76	17	8	1976	30.5°	28.6°	34.5	34.5
011-76	23	9	1976	28.0°	27.9°	32.1	32.4

Table 4. (Continued)

STATION: H-5 (Continued)

DEPTH: 19.5 M.

LATITUDE: 28°55.2'

LONGITUDE: 94°37.6'

Cruise	Day	Month	Year	Temperature °C		Salinity °/oo	
				Depth		Depth	
				Surface	Bottom	Surface	Bottom
012-76	18	10	1976	23.4°	23.8°	32.8	32.5
014-76	3	12	1976	16.2°	15.9°	35.0	35.1
001-77	17	1	1977	12.7°	12.9°	32.1	32.3
003-77	19	2	1977	16.7°	14.0°	33.0	36.3

STATION: H-6

DEPTH: 20.0 M.

LATITUDE: 28°49'

LONGITUDE: 94°46.1'

Cruise	Day	Month	Year	Temperature °C		Salinity °/oo	
				Depth		Depth	
				Surface	Bottom	Surface	Bottom
001-76	25	5	1976	26.5°	25.1°	30.0	34.0
004-76	7	7	1976	29.5°	28.5°	29.9	30.5
008-76	12	8	1976	29.5°	27.5°	32.1	33.6
009-76	17	8	1976	29.3°	28.0°	31.7	33.1
011-76	23	9	1976	28.0°	28.0°	32.5	32.9
012-76	18	10	1976	23.5°	24.0°	32.8	32.9
014-76	3	12	1976	16.7°	36.5°	25.2	34.6
003-77	19	2	1977	15.5°	14.2°	31.9	36.7

STATION: H-7

DEPTH: 23.2 M.

LATITUDE: 28°44.7'

LONGITUDE: 94°34.6'

Cruise	Day	Month	Year	Temperature °C		Salinity °/oo	
				Depth		Depth	
				Surface	Bottom	Surface	Bottom
004-76	7	7	1976	28.9°	29.0°	29.0	30.0
011-76	23	9	1976	28.0°	28.4°	32.5	35.6
012-76	18	10	1976	23.9°	23.8°	33.0	32.9
001-77	18	1	1977	13.1°	13.3°	33.0	33.6
002-77	9	2	1977	13.2°	13.2°	35.5	35.5

Table 5. The numbers of bottles released and recovered by cruises from May 1976 to February 1977

Cruise	Inclusive Dates	Total Released	Recoveries 0-15	16-30	30	% Recovered Within 30 Days
001-76	5/24-5/29	102	5	13	27	18
002-76	6/11	12	1	1	2	17
003-76	7/1-7/2	40	8	4	3	30
004-76	7/7	24	4	1	1	21
005-76	7/13	15	0	0	4	0
006-76	7/20	21	0	1	5	5
007-76	7/27	15	0	0	6	0
008-76	8/10-8/12	24	9	1	0	42
009-76	8/16-8/21	120	12	13	16	21
010-76	8/31	15	0	4	5	27
011-76	9/23	90	0	0	3	0
012-76	10/18	101	0	0	1	0
013-76	11/11	15	0	0	0	0
014-76	11/30-12/4	111	0	0	1	0
001-77	1/17-1/18	100	0	0	13	0
002-77	2/9-2/10	0	-	-	-	-
003-77	2/18-3/3	60	2	15	16	28
Totals		865	41	53	103	11

Table 6. Drift bottle releases and recoveries by cruise, station, and date, 1976, 1977

CRUISE NO.: 001-76

INCLUSIVE DATES: 5/24-5/19

Station	Latitude	Longitude	Release		Recovery			
			Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-1	29°00	94°49.5'	5-24-76	6	2	28°30'	96°12'	33
H-2	28°55.9'	94°45.5'	5-24-76	6	5	28°23.1'	96°23'	52
					7	28°18.6'	96°27.5'	301
					10	28°20.5'	96°23.5'	22
H-3	28°52'	94°41.5'	5-24-76	6	11	28°07.5'	96°46.5'	21
					13	28°08'	96°46'	21
					14	28°04'	96°51'	31
					17	28°09'	96°42'	27
					18	28°18'	96°27.5'	17
					19	28°04'	96°51'	218
			5-25-76	6	32	27°50'	97°03'	17
					33	27°57.7'	96°57.4'	46
					34	28°23.1'	96°23'	52
					35	28°29.2'	96°13.5'	71
H-4	28°48.7'	94°38.5'	5-24-76	6	37	27°46.5'	97°06.5'	17
H-5	28°55.2'	94°37.6'	5-25-76	6	25	28°30.5'	96°11'	68
					26	28°30.5'	96°11'	32
					28	28°30.6'	96°11.3'	70
					29	28°29.5'	95°13'	32
H-6	28°49'	94°46.1	5-25-76	6	30	28°49'	95°30'	19
					38	28°37'	96°22.5'	26
H-8	28°37.5'	94°28'	5-25-76	6	39	28°14'	96°36.5'	20
					44	28°23'	96°24.5'	31
					45	28°49'	95°31'	31
					46	28°34.5'	96°28'	47

Table 6. (Continued)

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CRUISE NO.: 001-76 (Continued)

INCLUSIVE DATES: 5/24-5/29

Station	Latitude	Longitude	Release		Recovery			
			Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-8	28°37.5'	94°28'	5-25-76	6	47	28°44.5'	95°40'	34
					48	28°33.5'	96°04'	55
H-9	28°25.8'	94°17.5'	5-25-76	6	50	29°46.2'	93°28.4'	78
					51	29°24.2'	94°43.4'	177
					52	29°46.2'	93°28.4'	82
					53	29°05.4'	95°06.5'	100
H-12	28°44'	95°18'	5-28-76	6	74	29°11.5'	94°57.5'	7
					75	28°53.5'	95°21.5'	13
					78	29°13'	94°55'	8
H-13	28°32.5'	95°07'	5-27-76	6	NONE			
H-14	28°20.7'	94°56.7'	5-27-76	6	63	28°36.7'	95°56'	27
					64	28°45.5'	95°37.5'	36
					65	28°20.5'	96°23.5'	22
					66	28°39.5'	95°49.5'	32
H-15	28°09.3'	94°46'	5-26-76	6	56	28°51.5'	95°39'	57
					58	28°36.5'	95°58'	31
H-17	28°30'	95°49'	5-29-76	6	NONE			
H-18	28°18.5'	95°38'	5-29-76	6	90	27°41.7'	97°09.3'	14
					91	27°41.7'	97°09.3'	14
H-19	28°07'	95°27.5'	5-29-76	6	97	28°03.5'	96°51'	100
H-20	27°54.5'	95°16'	5-29-76	6	98	28°34.5'	96°27.5'	38
					99	28°23.5'	96°24.5'	20

CRUISE NO: 002-76

INCLUSIVE DATES: 6/11

Station	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-5	28°55.2'	94°37.6'	6-11-76	6	106	29°42.2'	93°47.3'	159
H-6	28°49'	94°46.1'	6-11-76	6	110	28°53.5'	95°25.4'	12
					113	29°25.3'	94°41'	27

Table 6. (Continued)

CRUISE NO.: 003-76

INCLUSIVE DATES: 7/1-7/2

Station	Latitude	Longitude	Release		Recovery			
			Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
S-1	29°04.4'	94°40.9'	7-1-76	5	117	28°34.5'	96°01.8'	20
			7-2-76	5	151	29°11.5'	94°57.5'	10
					152	29°10'	95°00'	10
					154	29°11.1'	94°57.2'	11
S-2	28°59.2'	94°41.2'	7-1-76	5	122	29°01.5'	95°11.1'	13
					123	29°11.1'	94°57.2'	59
					124	28°58.3'	95°15.5'	19
S-3	28°54.2'	94°41.5'	7-1-76	15	129	29°02.2'	95°10.6'	13
					130	29°05'	95°07.1'	9
					132	29°26.7'	94°37.9'	19
					135	29°11.1'	94°57.2'	13
					140	29°09'	95°01.5'	110
			7-2-76	10	141	29°11.5'	94°57.5'	14
					144	29°46.2'	93°28.4'	46
					149	29°30'	94°31'	17

CRUISE No.: 004-76

INCLUSIVE DATES: 7/7

Station	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-3	28°52'	94°41.5'	7-7-76	6	164	26°36'	97°17.4'	117
H-5	28°55.2'	94°37.6'	7-7-76	6	171	28°53.8'	95°21'	8
H-6	28°49'	94°46.1'	7-7-76	6	162	28°23.1'	96°23'	7
					163	28°23.1'	96°23'	7
					12631	28°31.5'	96°08.8'	16
					12633	28°36.2'	95°57.4'	11

Table 6. (Continued)

CRUISE NO.: 005-76

INCLUSIVE DATES: 7/13

Station	Release				Recovery			
	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-2	28°55.9'	94°45.5'	7-13-76	3	-NONE-			
H-3	28°52'	94°41.5'	7-13-76	3	-NONE-			
H-4	28°48.7'	94°38.7'	7-13-76	3	-NONE-			
S-4	28°53.5'	94°36'	7-13-76	3	185	28°05'	96°49.5'	103
S-5	28°57.2'	94°39.7'	7-13-76	3	12630	26°29.8'	97°14.9'	179

CRUISE NO.: 006-76

INCLUSIVE DATES: 7/20

Station	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-1	29°00'	94°49.5'	7-20-76	7	12638	29°30'	94°30.7'	47
					12640	29°35'	94°17.9'	30
					12642	29°45'	93°38.8'	38
H-2	28°55.9'	94°45.5'	7-20-76	7	-NONE-			
H-4	28°48.7'	94°38.5'	7-20-76	7	12651	29°23.7'	94°42.8'	44
					12653	29°10.5'	94°59.1'	66
					12657	29°11.1'	94°57.2'	47

CRUISE NO.: 007-76

IN~LUSIVE DATES: 7/27

Station	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-2	28°55.9'	94°45.5'	7-27-76	5	12660	28°41.5'	95°45'	53
H-3	28°52'	94°41.5'	7-27-76	5	12666	28°21'	96°23.7'	123
					12667	28°39.4'	95°50'	59
					12668	28°38.5'	95°51.5'	49
H-4	28°48.7'	94°38.5'	7-27-76	5	12671	28°45.5'	95°37.5'	51
					12672	28°45'	95°38.4'	40

Table 6. (Continued)

CRUISE NO.: 008-76

INCLUSIVE DATES: 8/10-8/12

Station	Latitude	Longitude	Release Date Occupied	Release Total Number	Recovery Bottle Number	Recovery Latitude	Recovery Longitude	Recovery Days Out
H-3	28°52'	94°41.5'	8-11-76	8	12683	28°44.7'	95°39'	12
					12685	28°53.4'	95°21.5'	9
					12688	28°39.7'	95°49'	17
					12689	29°01.6'	95°11'	8
H-5	28°55.2'	94°37.6'	8-10-76	8	12674	29°11.5'	94°57.5'	9
					12675	29°00'	95°13.1'	11
					12677	29°05.7'	95°06.1'	8
					12678	28°53.4'	95°21.5'	10
					12679	28°57'	95°17.4'	10
H-6	28°49'	94°46.1'	8-12-76	8	12695	28°28.5'	96°15'	15

CRUISE NO.: 009-76

INCLUSIVE DATES: 8/16-8/21

Station	Latitude	Longitude	Release Date Occupied	Release Total Number	Recovery Bottle Number	Recovery Latitude	Recovery Longitude	Recovery Days Out
H-1	29°00'	94°49.5'	8-16-76	6	12698	28°34.8'	96°01.2'	7
					12700	28°37'	95°55.6'	7
H-2	28°55.9'	94°45.5'	8-16-76	6	12704	28°43.5'	95°41.3'	17
					12707	28°34.8'	96°01.2'	9
					12708	28°34.8'	96°01.2'	9
H-3	28°52'	94°41.5'	8-17-76	6	12721	28°32.4'	96°06.9'	24
H-4	28°48.7'	94°38.5'	8-17-76	6	12731	28°20.5'	96°23.5'	37
H-5	28°55.2'	94°37.6'	8-17-76	6	12723	28°48.5'	95°18.5'	11
H-6	28°49'	94°46.1'	8-17-76	6	12710	28°38.5'	95°51.5'	40
					12712	28°44.5'	95°39.2'	11
					12715	28°44.5'	95°39.2'	11
H-8	28°37.5'	94°28'	8-17-76	6	NONE			

Table 6. (Continued)

CRUISE NO.: 008-76 (Continued)

INCLUSIVE DATES: 8/10-8/13

Station	Latitude	Longitude	Release Date Occupied	Release Total Number	Recovery Bottle Number	Recovery Latitude	Recovery Longitude	Recovery Days Out
H-9	26°25.8'	94°17.5'	8-18-76	6	12743	28°34.9'	97°13.2'	49
					12745	28°12'	96°40'	67
H-10	28°14.7'	94°08.5'	8-18-76	6	12746	27°30'	97°15.6'	39
					12749	27°49.3'	97°03.5'	40
					12751	27°42.5'	97°08.8'	39
H-11	28°02.5'	93°56.7'	8-18-76	6		NONE		
H-12	28°44'	95°18'	8-21-76	6	12804	28°48.3'	95°32'	21
					12805	28°32.5'	96°07'	11
H-13	28°12.5'	95°07'	8-21-76	6	12808	27°42.2'	97°08.9'	26
					12809	27°10.2'	97°22.1'	50
					12810	27°50'	97°03'	28
					12811	28°04.6'	96°49.8'	22
H-14	28°20.7'	94°56.7'	8-19-76	6	12771	28°12'	96°40'	67

CRUISE NO.: 009-76

INCLUSIVE DATES: 8/16-8/21

Station	Latitude	Longitude	Release Date Occupied	Release Total Number	Recovery Bottle Number	Recovery Latitude	Recovery Longitude	Recovery Days Out
H-14	28°20.7'	94°56.7'	8-19-76	6	12772	28°12'	°40'	18
					12774	28°12'	96°40'	19
H-15	28°09.3	94°46'	8-19-76	6	12767	28°12'	96°40'	66
					12760	28°04'	96°50.5'	39
					12762	28°03.8'	96°50.8'	36
H-16	27°57.5'	94°35.5'	8-19-76	6	12794	28°39.4'	95°49.8'	8
H-17	28°30'	95°49'	8-20-76	6	12795	28°30.5'	96°10'	12
					12796	28°26.7'	96°24.2'	18
					12797	28°18.3'	96°28.1'	15

Table 6. (Continued)

CRUISE NO.: 009-76 (Continued)

INCLUSIVE DATES: 8/15-8/21

Station	Latitude	Longitude	Release Date Occupied	Release Total Number	Recovery Bottle Number	Recovery Latitude	Recovery Longitude	Recovery Days Out
H-18	28°18.5'	95°38'	8-20-76	6	12788	28°04'	96°50.5'	38
					12789	28°18'	96°29'	15
					12790	28°06.1'	96°48'	82
					12791	28°12'	96°40'	17
H-19	28°07'	95°27.5'	8-20-76	6	12792	28°12'	96°40'	18
					12783	27°50'	97°03'	25
					12785	27°50'	97°03'	31
H-20	27°54.5'	95°16'	8-20-76	6	12787	28°20'	96°24'	26
					12776	28°12'	96°40'	66
CRUISE NO.: 010-76								
INCLUSIVE DATES: 8/31								
H-1	29°00'	94°49.5'	8-31-76	5	12815	28°20.5'	96°23.5'	17
H-3	28°52'	94°41.5'	8-31-76	5	12817	28°32.4'	96°07'	195
					12819	28°23.8'	96°22.2'	55
H-7	28°44.7'	94°34.6'	8-31-76	5	12821	28°12'	96°40'	55
					12824	28°26.7'	96°24.2'	19
					12825	28°24.3'	96°24'	20
					12826	27°49.8'	97°03'	36
					12827	28°24.3'	96°24'	20
CRUISE NO.: 011-76								
INCLUSIVE DATES: 9/23								
H-1	29°00'	94°49.5'	9-23-76	10	12828	26°19.4'	97°12'	173
H-2	28°55.9'	94°45.5'	9-23-76	10	------NONE------			
H-3	28°52'	94°41.5'	9-23-76	10	------NONE------			
H-4	28°48.7'	94°38.5'	9-23-76	10	------NONE------			
H-5	28°55.2'	94°37.6'	9-23-76	15	13018	27°08.1'	97°22.5'	151
H-6	28°49'	94°46.1'	9-23-76	15	13029	26°13.6'	97°10.5'	39
H-7	28°44.7'	94°34.6'	9-23-76	20	------NONE------			

Table 6. (Continued)

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CRUISE NO.: 012-76

INCLUSIVE DATES: 10/18

Station	Release				Recovery			
	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-1	29°00'	94°49.5'	10-18-76	15	13043	18°26.2'	93°11.9'	58
H-2	28°55.9'	94°45.5'	10-18-76	10		NONE		
H-3	28°52'	94°41.5'	10-18-76	15		NONE		
H-4	28°48.7'	94°38.5'	10-18-76	10		NONE		
H-5	28°55.2'	94°37.6'	10-18-76	16		NONE		
H-6	28°49'	94°46.1'	10-18-76	15		NONE		
H-7	28°44.7'	94°34.6'	10-18-76	20		NONE		

CRUISE NO.: 013-76

INCLUSIVE DATES: 11/11

Station	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-1	29°00'	94°49.5'	11-11-76	15		NONE		

CRUISE NO.: 014-76

INCLUSIVE DATES: 11/30-12/4

Station	Latitude	Longitude	Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-1	29°00'	94°49.5'	12-4-76	6		NONE		
H-2	28°55.9'	94°45.5'	12-4-76	6		NONE		
H-4	28°48.7'	94°38.5'	12-4-76	6		NONE		
H-5	28°55.2'	94°37.6'	12-3-76	6		NONE		
H-6	28°49'	94°46.1'	12-3-76	6		NONE		
H-8	28°37.5'	94°28'	11-30-76	6		NONE		
H-9	28°25.8'	94°17.5'	11-30-76	6		NONE		
H-10	28°14.7'	94°06.5'	12-1-76	9		NONE		
H-11	28°02.5'	93°56.7'	12-1-76	6		NONE		

Table 6. (Continued)

CRUISE NO.: 014-76 (Continued)

INCLUSIVE DATES: 11/10-12/4

Station	Latitude	Longitude	Release		Recovery			
			Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-12	28°44'	95°18'	12-3-76	6	----------------------NONE----------------------			
H-13	28°32.5'	95°07'	12-3-76	6	----------------------NONE----------------------			
H-14	28°20.7'	94°56.7'	12-1-76	6	----------------------NONE----------------------			
H-15	28°09.3'	94°48'	12-1-76	6	----------------------NONE----------------------			
H-16	27°57.5'	94°35.5'	12-1-76	6	----------------------NONE----------------------			
H-17	28°30'	95°49'	12-2-76	6	----------------------NONE----------------------			
H-18	28°18.5'	95°38'	12-2-76	6	----------------------NONE----------------------			
H-19	28°07'	95°27.5'	12-2-76	6	----------------------NONE----------------------			
H-20	27°54.5'	95°16'	12-2-76	6	13207	27°46.4'	97°05.8'	121

CRUISE NO.: 001-77

INCLUSIVE DATES: 1/17-1/18

H-1	29°00'	94°49.5'	1-18-77	25	12884	25°02.3'	97°32'	59
					12887	26°06.7'	97°10'	61
H-2	28°55.9'	94°45.5'	1-18-77	15	13341	26°07.8'	97°10'	48
H-3	28°52'	94°41.5'	1-18-77	20	13295	26°10'	97°10.6'	47
					13297	26°07.8'	97°10'	49
					13300	26°24.2'	97°13.2'	50
					13301	25°28.5'	97°19'	51
					13302	26°17.9'	97°11.6'	43
H-4	28°48.7'	94°38.5'	1-17-77	15	13330	25°55.7'	97°08.5'	62
					13333	27°18'	97°20.4'	48
H-5	28°55.2'	94°37.6'	1-17-77	10	13323	27°18.6'	97°20.3'	48
					13326	26°47.9'	97°20.8'	49
H-7	28°44.7'	94°34.6'	1-18-77	15	13283	23°33'	97°46.3'	67

Table 6. (Continued)

CRUISE NO.: 003-77

INCLUSIVE DATES: 2/18-3/3

Station	Latitude	Longitude	Release		Recovery			
			Date Occupied	Total Number	Bottle Number	Latitude	Longitude	Days Out
H-1	29°00'	94°49.5'	2-19-77	6	12915	29°00.6'	95°12.5'	6
					12916	29°00.6'	95°12.5'	4
H-4	28°48.7'	94°39.5'	2-19-77	6	12931	26°36.7'	97°17.5'	29
					12933	27°48.4'	97°04.3'	18
					12935	27°12.3'	97°22'	26
H-5	28°55.2'	94°37.6'	2-19-77	6	12918	27°25.2'	97°18.1'	22
					12919	27°31.7'	97°14.8'	40
					12920	27°13.8'	97°21.5'	22
H-6	28°49'	94°46.1'	2-19-77	6	12926	23°33'	97°46.3'	35
					12927	27°13.7'	97°21.6'	22
H-8	28°37.5'	94°28'	2-19-77	6	12937	27°18.6'	97°20.4'	30
					12938	27°34.4'	97°13.4'	26
H-10	28°14.7'	94°06.5'	2-20-77	6	12941	27°21.7'	97°19.4'	27
					12944	27°48.4'	97°04.3'	24
					12945	26°36'	97°17.1'	37
					12946	27°44'	97°07.5'	25
					12947	27°39.8'	97°10.4'	30
H-11	28°12.5'	95°03'	2-19-77	6	12906	27°06.8'	97°22.6'	38
					12909	27°08.8'	97°22.4'	30
					12910	26°58'	97°22.6'	36
					12911	26°21.3'	97°12.2'	22
H-14	28°29.7'	94°58.7'	2-19-77	6	12902	27°38.1'	97°11.4'	30
					12904	26°13.6'	97°10.5'	36
H-16	28°14.5'	95°10'	2-18-77	6	-----NONE-----			
H-18	28°07'	95°27.5'	2-18-77	6	-----NONE-----			

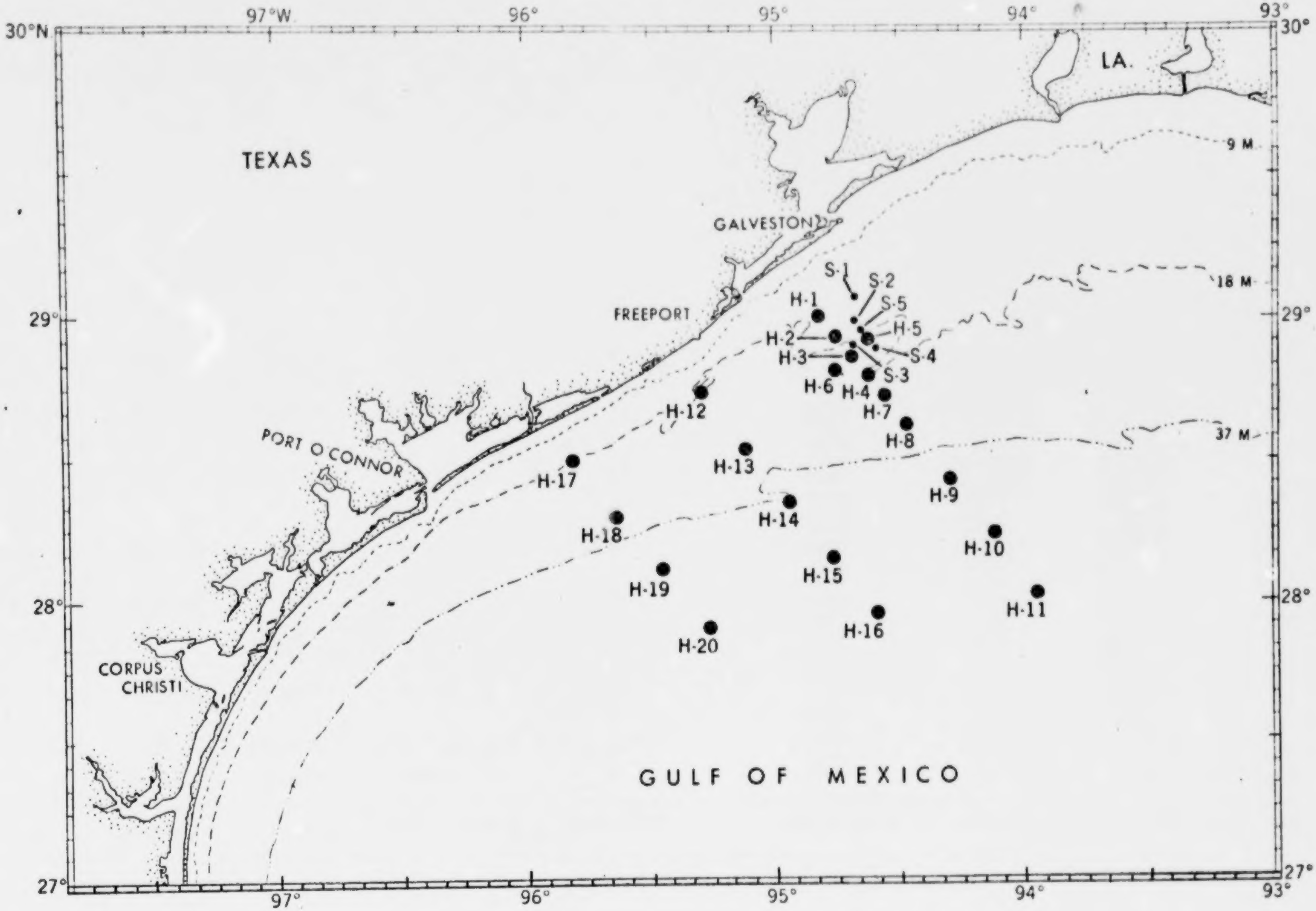

97°W
96°
95°
94°
93°
30°N
30°
29°
28°
27°
TEXAS
LA.
GALVESTON
FREEPORT
PORT O'CONNOR
CORPUS CHRISTI
GULF OF MEXICO
9 M
18 M
37 M
S-1
S-2
S-5
H-5
S-4
S-3
H-1
H-2
H-3
H-6
H-4
H-7
H-8
H-9
H-10
H-11
H-12
H-13
H-14
H-15
H-16
H-17
H-18
H-19
H-20

Figure 1. Drift bottle release stations for cruises during May 1976 to February 1977.

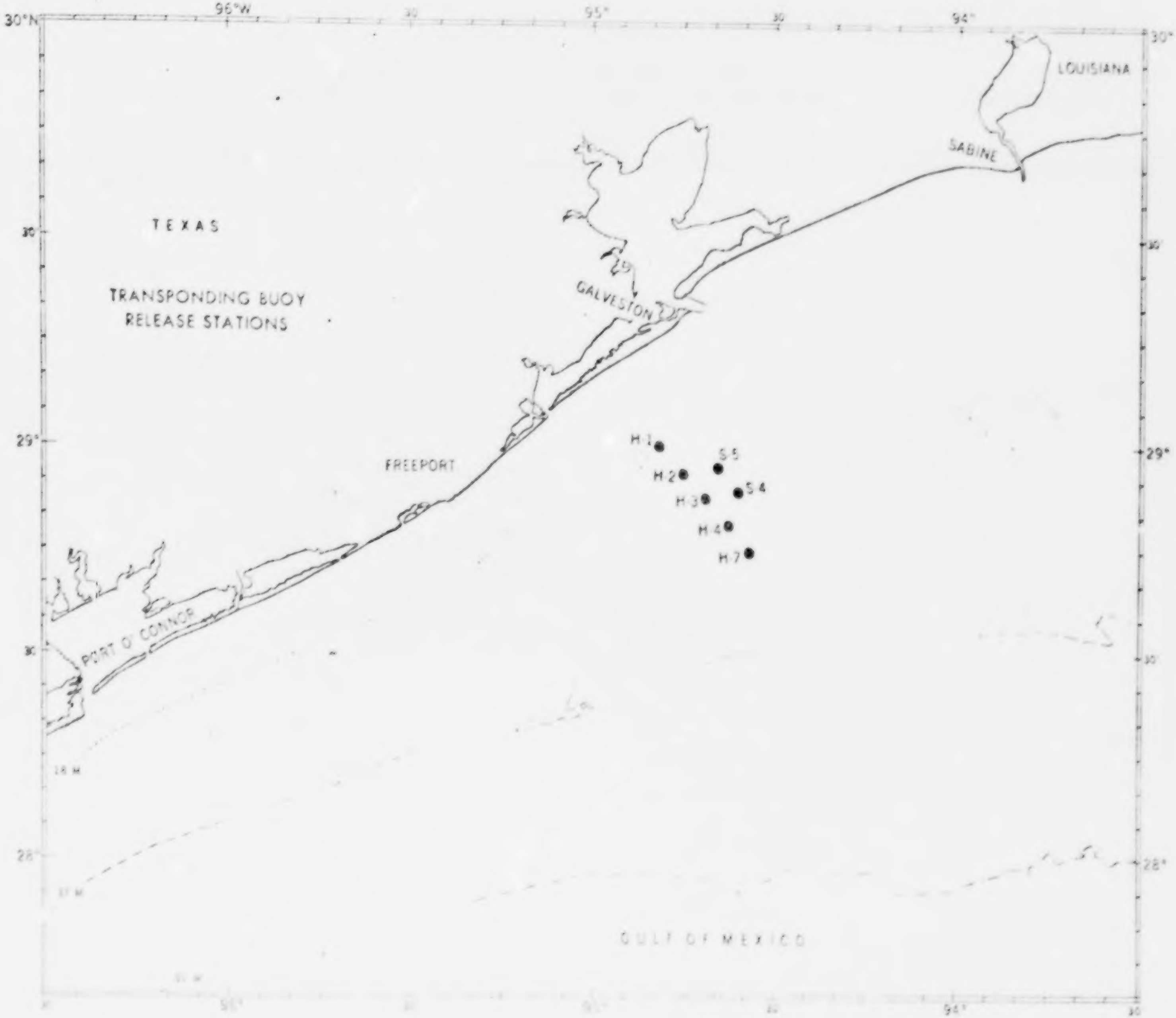

TRANSPONDING BUOY
RELEASE STATIONS
TEXAS
LOUISIANA
SABINE
GALVESTON
FREEPORT
PORT O' CONNOR
GULF OF MEXICO
H-1
H-2
H-3
H-4
H-7
S-5
S-4
18 M
37 M
30°N
30
29°
28°
30°
96°W
95°
94°
18 M
37 M

Figure 2. Transponding buoy release stations during cruises from July 1976 to February 1977.

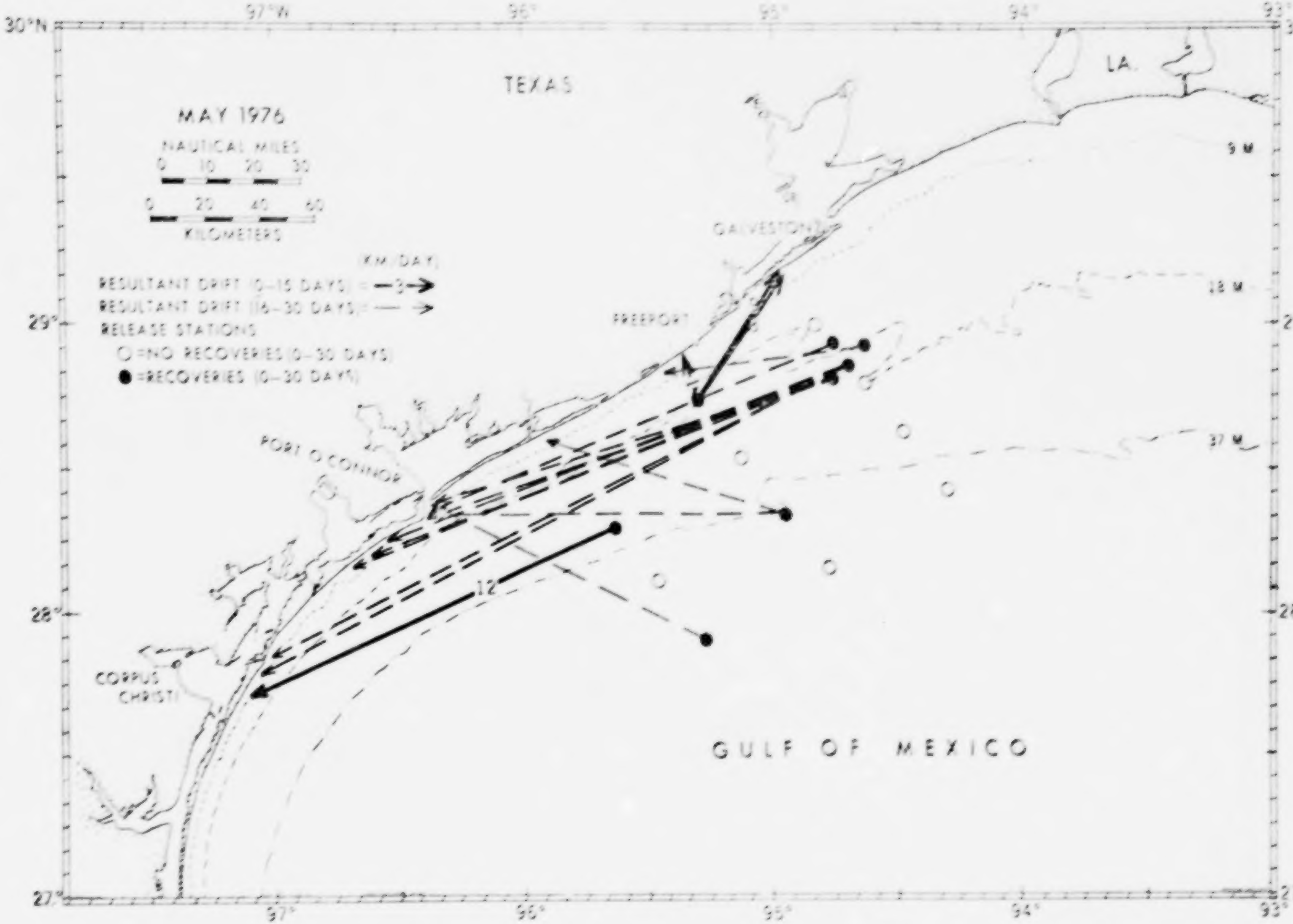

30°N
97°W
96°
95°
94°
93°
30°
29°
28°
27°
TEXAS
LA.
MAY 1976
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS) = — →
RELEASE STATIONS
○=NO RECOVERIES (0–30 DAYS)
●=RECOVERIES (0–30 DAYS)
GALVESTON
FREEPORT
PORT O'CONNOR
CORPUS CHRISTI
9 M
18 M
37 M
12
GULF OF MEXICO

Figure 3. Surface circulation deduced from recoveries of drift bottles released on Cruise 001-76, May 24-29, 1976

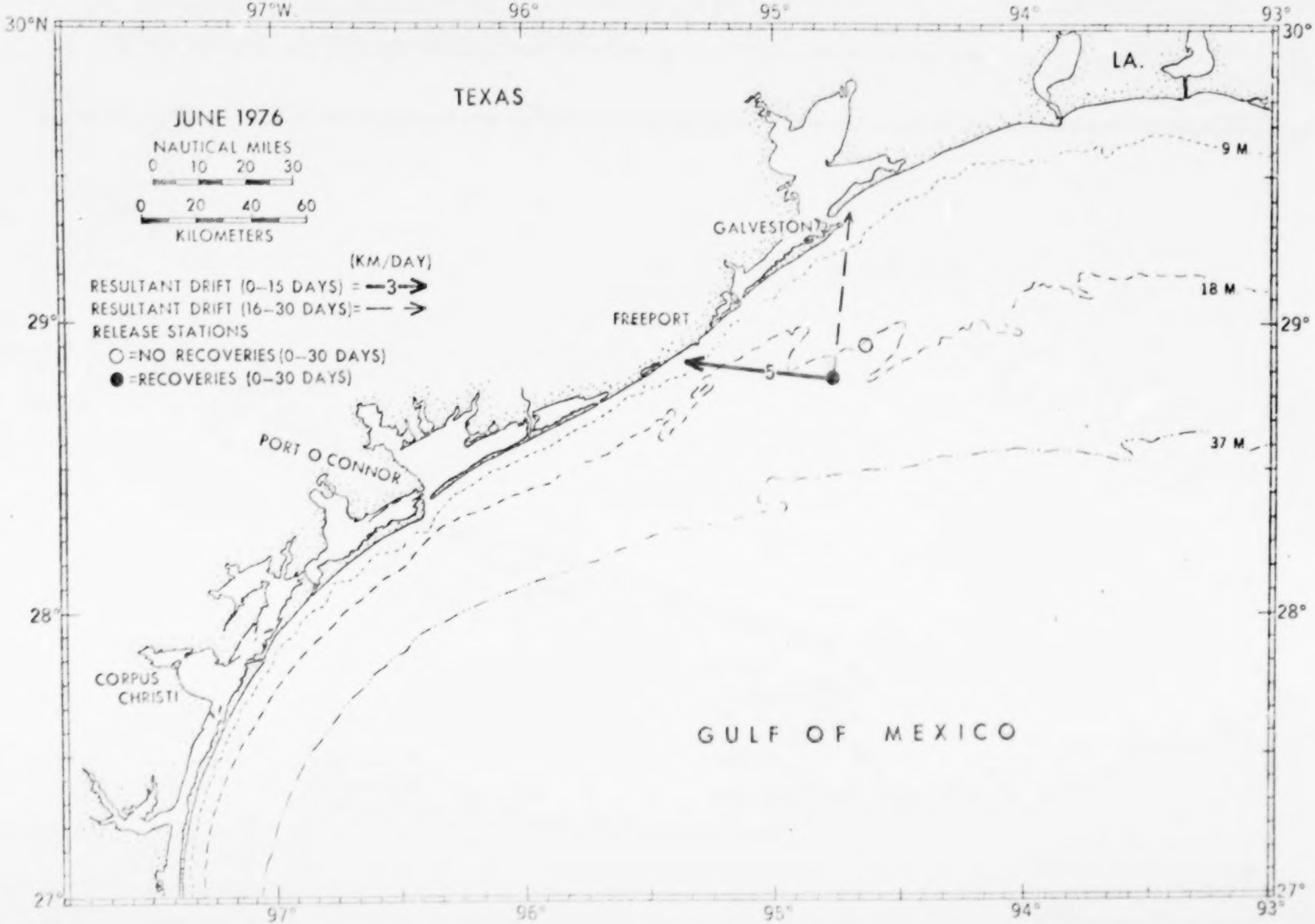

30°N
97°W
96°
95°
94°
93°
30°
29°
28°
27°
TEXAS
LA.
JUNE 1976
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS) = — →
RELEASE STATIONS
○ =NO RECOVERIES (0–30 DAYS)
● =RECOVERIES (0–30 DAYS)
GALVESTON
FREEPORT
PORT O CONNOR
CORPUS CHRISTI
5
9 M
18 M
37 M
GULF OF MEXICO

Figure 4. Surface circulation deduced from recoveries of drift bottles released on Cruise 002-76, June 11, 1976

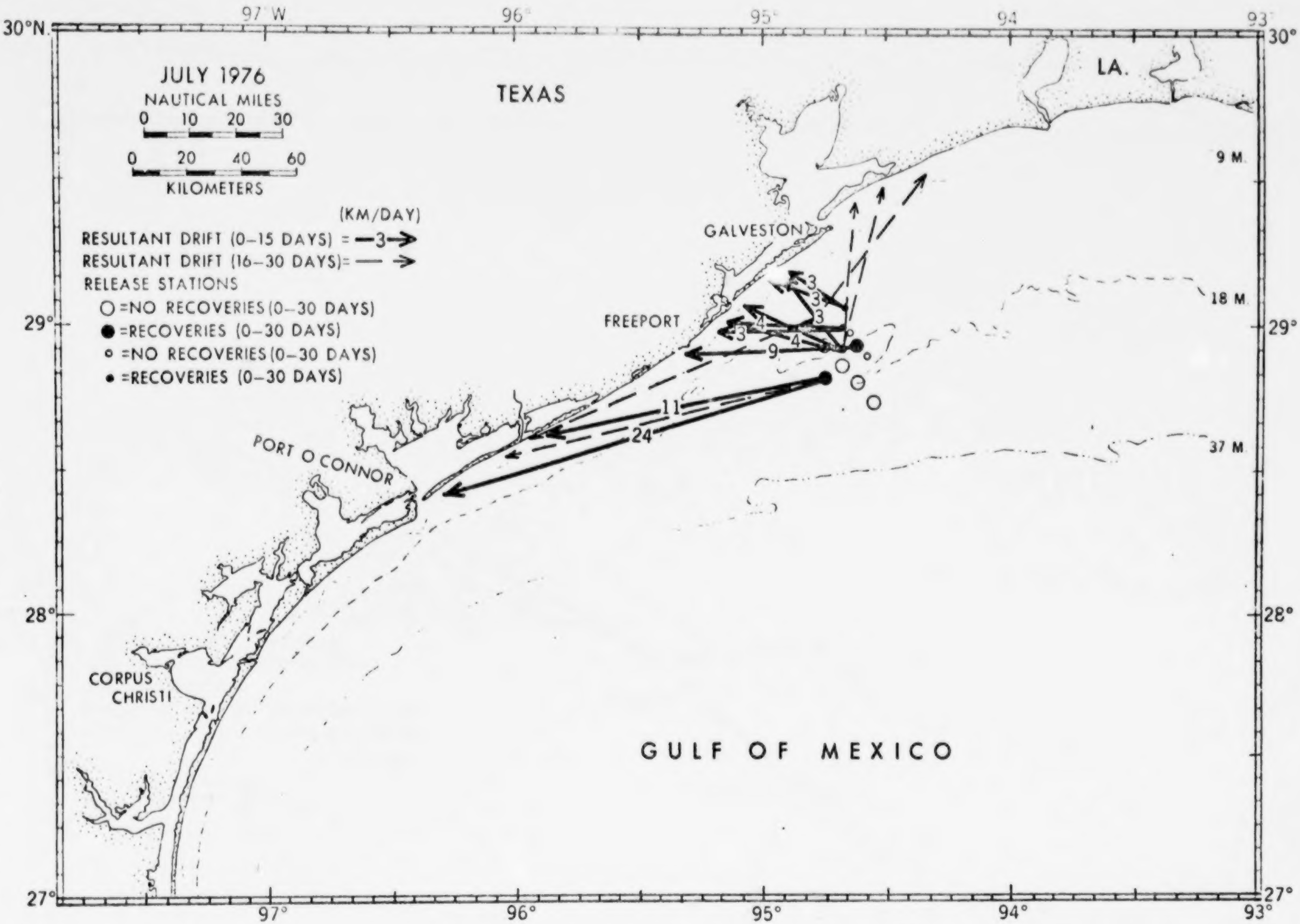

JULY 1976
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS)= — →
RELEASE STATIONS
○ =NO RECOVERIES (0–30 DAYS)
● =RECOVERIES (0–30 DAYS)
∘ =NO RECOVERIES (0–30 DAYS)
• =RECOVERIES (0–30 DAYS)
TEXAS
LA.
GALVESTON
FREEPORT
PORT O CONNOR
CORPUS CHRISTI
GULF OF MEXICO
9 M.
18 M.
37 M.
3
3
3
3
4
4
3
9
11
24
30°N.
29°
28°
27°
30°
29°
28°
27°
97° W
96°
95°
94°
93°
97°
96°
95°
94°
93°

Figure 5. Surface circulation deduced from recoveries of drift bottles released on Cruises 003-76 - 007-76, July 1-2, 7, 13, 20, and 27, 1976

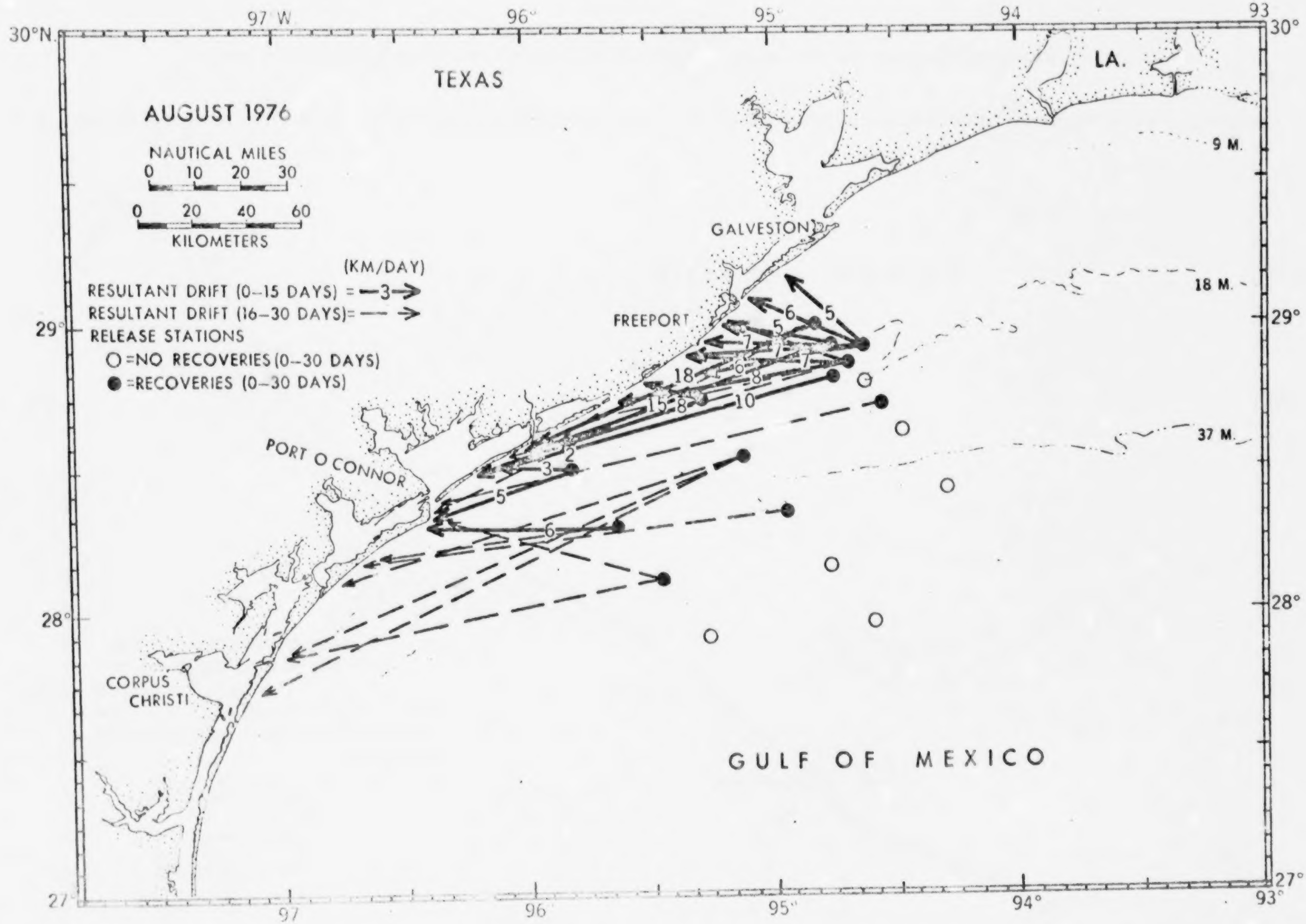

97 W
96°
95°
94
93
30°N
30°
29°
28°
27°
97
96
95°
94°
93°
TEXAS
LA.
AUGUST 1976
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS)= — — →
RELEASE STATIONS
○ =NO RECOVERIES (0–30 DAYS)
● =RECOVERIES (0–30 DAYS)
GALVESTON
FREEPORT
PORT O CONNOR
CORPUS CHRISTI
GULF OF MEXICO
9 M.
18 M.
37 M.
5
6
5
7
7
7
6
8
18
15
8
10
2
3
5
6

Figure 6. Surface circulation deduced from recoveries of drift bottles released on Cruises 008-76 - 010-76, August 9-12, 16-21, 31, 1976

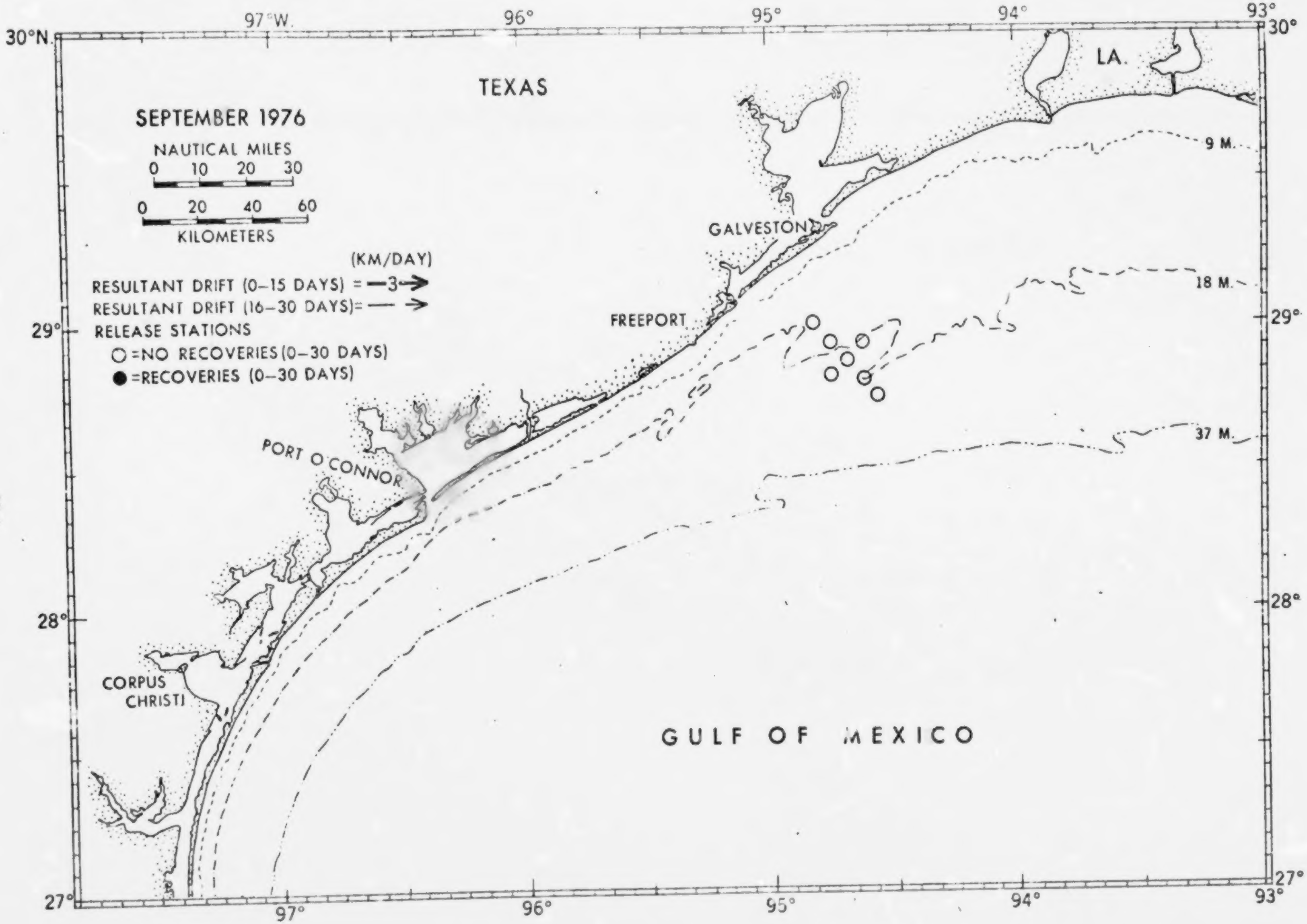

SEPTEMBER 1976
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS)= —— →
RELEASE STATIONS
○ =NO RECOVERIES (0–30 DAYS)
● =RECOVERIES (0–30 DAYS)
TEXAS
LA.
GALVESTON
FREEPORT
PORT O'CONNOR
CORPUS CHRISTI
GULF OF MEXICO
9 M.
18 M.
37 M.
97°W.
96°
95°
94°
93°
97°
30°N.
29°
28°
27°
30°

Figure 7. Surface circulation deduced from recoveries of drift bottles released on Cruise 011-76, September 23, 1976

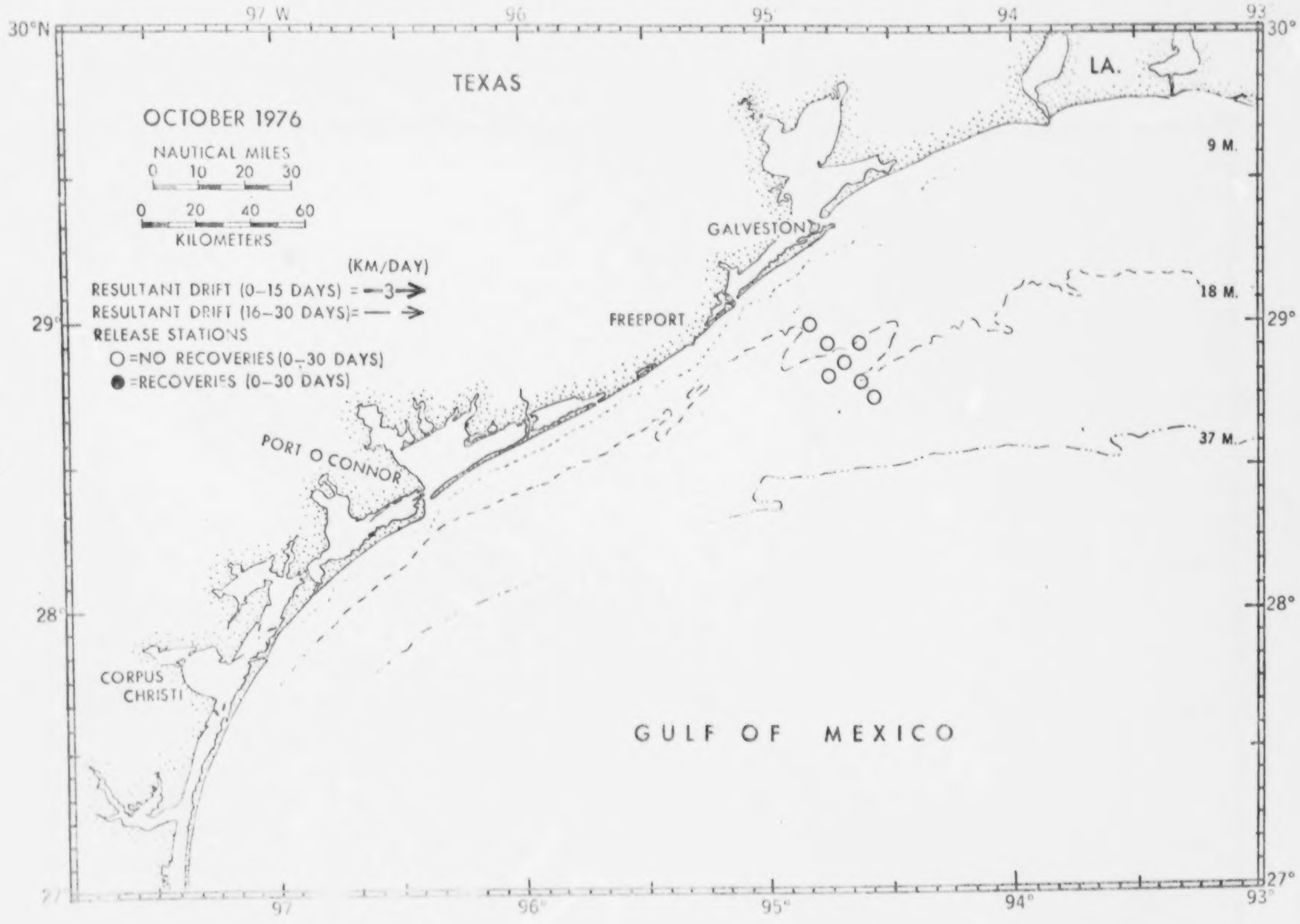

30°N
97 W
96
95
94
93
30°
29°
28°
27°
97
96°
95°
94°
93°
TEXAS
LA.
OCTOBER 1976
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS)= — →
RELEASE STATIONS
○ =NO RECOVERIES (0–30 DAYS)
● =RECOVERIES (0–30 DAYS)
GALVESTON
FREEPORT
PORT O CONNOR
CORPUS CHRISTI
9 M.
18 M.
37 M.
GULF OF MEXICO

Figure 8. Surface circulation deduced from recoveries of drift bottles released on Cruise 012-76, October 18, 1976

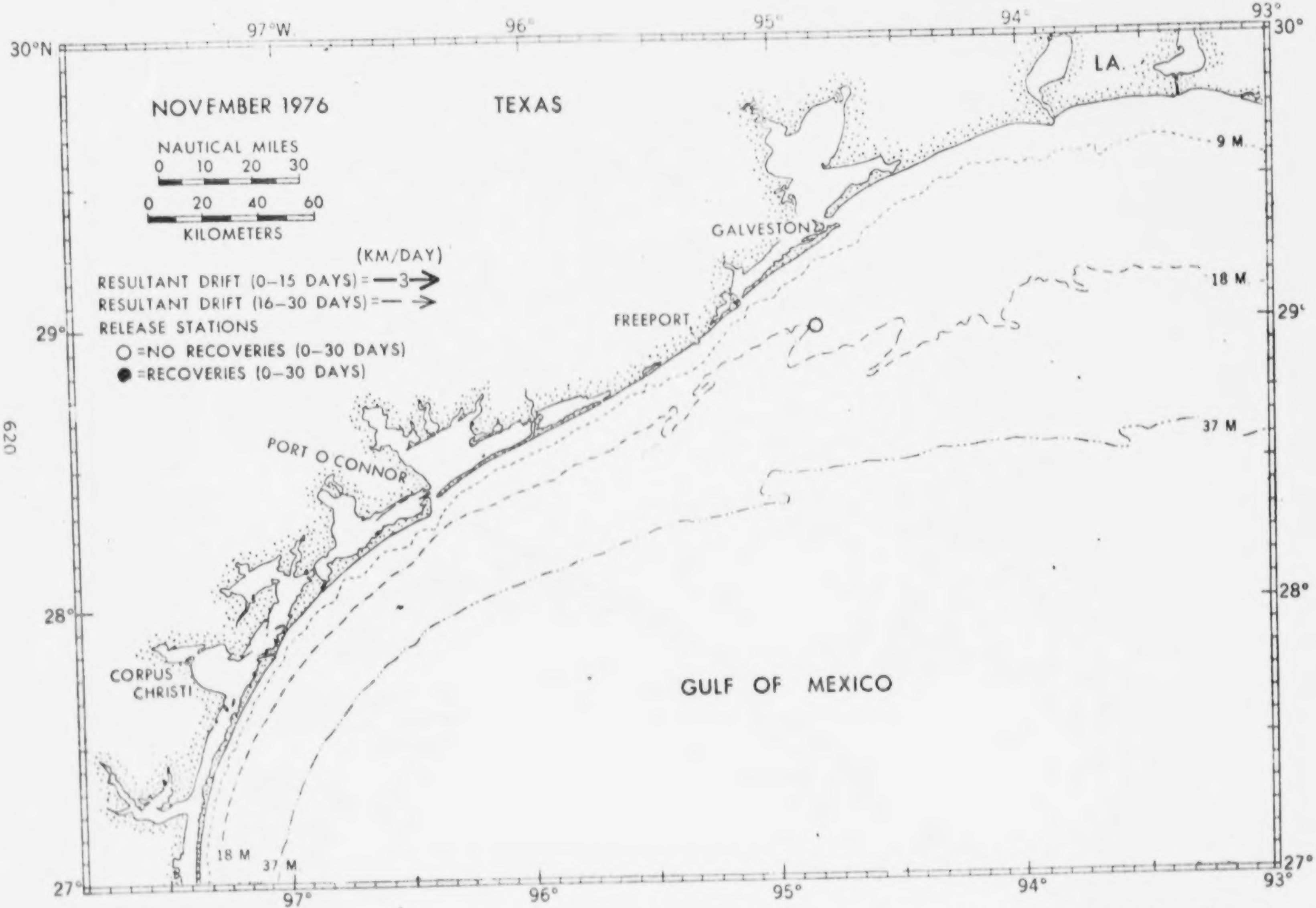

30°N
97°W
96°
95°
94°
93°
30°
NOVEMBER 1976
TEXAS
LA.
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS) = — →
RELEASE STATIONS
○ = NO RECOVERIES (0–30 DAYS)
● = RECOVERIES (0–30 DAYS)
GALVESTON
FREEPORT
PORT O CONNOR
CORPUS CHRISTI
GULF OF MEXICO
9 M
18 M
37 M
29°
28°
27°

Figure 9. Surface circulation deduced from recoveries of drift bottles released on Cruise 013-76, November 11, 1976.

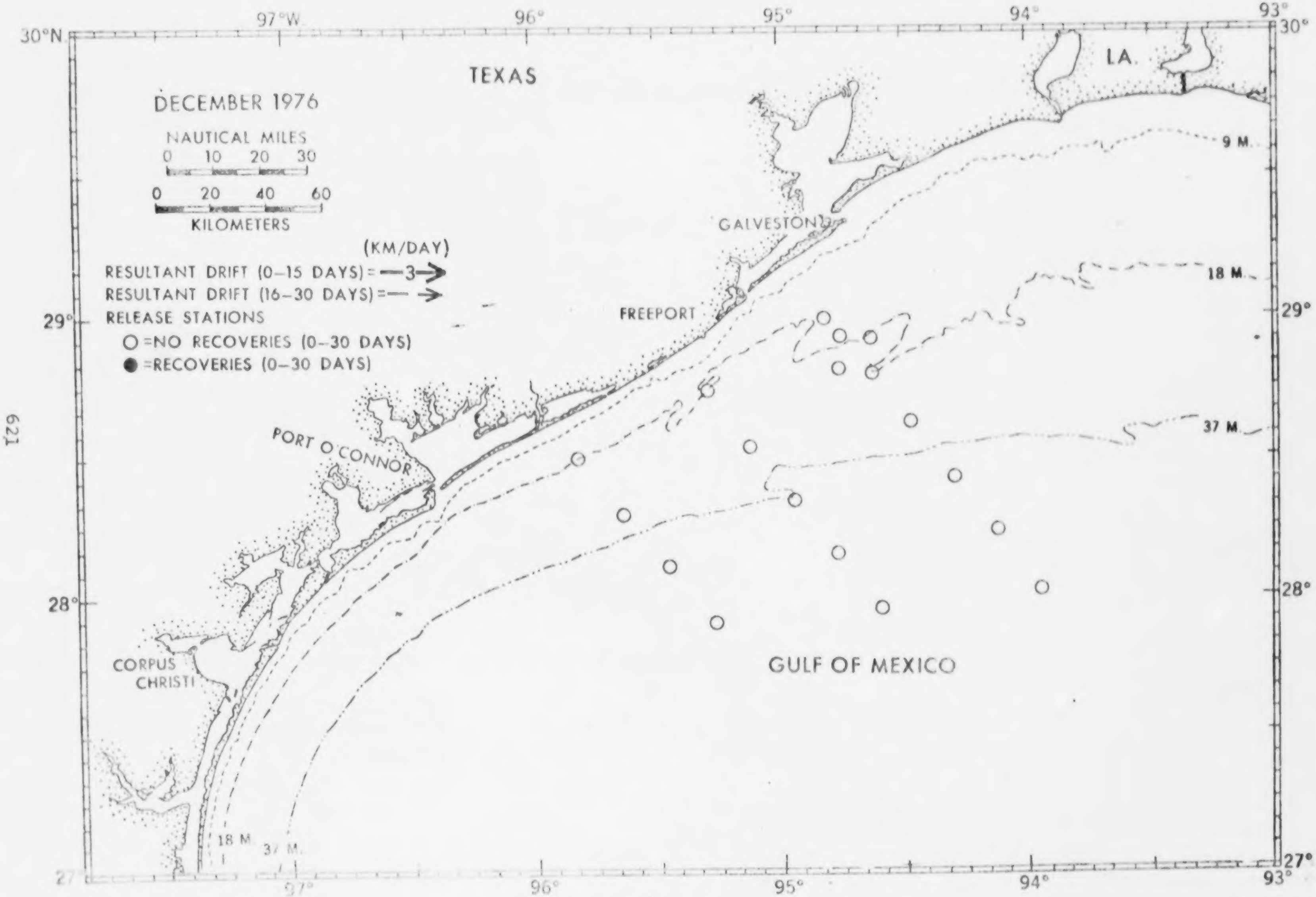

97°W
96°
95°
94°
93°
30°N
30°
29°
28°
27°
97°
TEXAS
LA.
DECEMBER 1976
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS) = — →
RELEASE STATIONS
○ =NO RECOVERIES (0–30 DAYS)
● =RECOVERIES (0–30 DAYS)
GALVESTON
FREEPORT
PORT O'CONNOR
CORPUS CHRISTI
9 M.
18 M.
37 M.
GULF OF MEXICO

Figure 10. Surface circulation derived from recoveries of drift bottles released on Cruise 014-76, November 30-December 4, 1976.

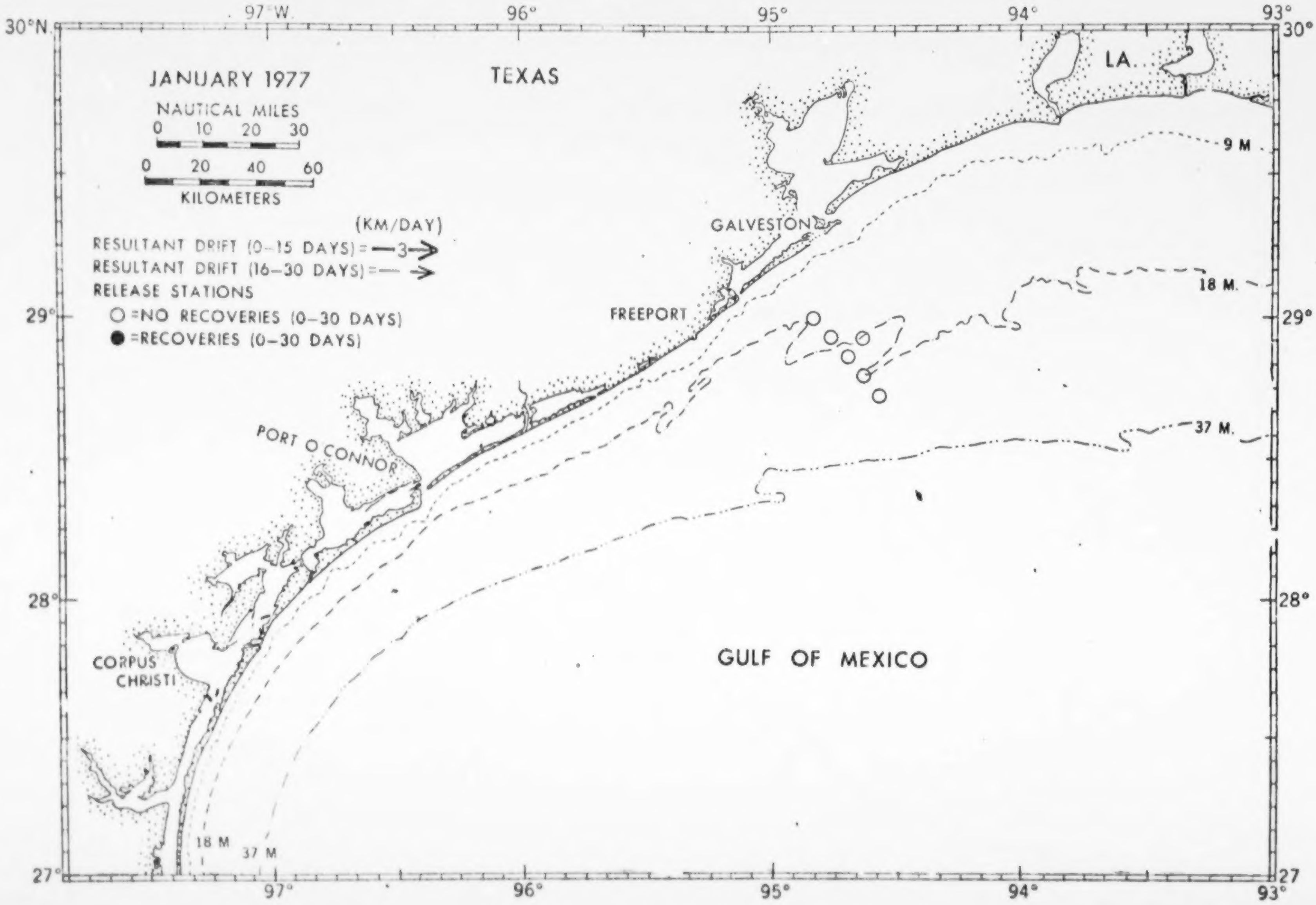

JANUARY 1977
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS) = — →
RELEASE STATIONS
○ =NO RECOVERIES (0–30 DAYS)
● =RECOVERIES (0–30 DAYS)
TEXAS
LA.
GALVESTON
FREEPORT
PORT O CONNOR
CORPUS CHRISTI
GULF OF MEXICO
9 M
18 M.
37 M.
18 M
37 M
30°N
29°
28°
27°
30°
29°
28°
27
97° W
96°
95°
94°
93°
97°
96°
95°
94°
93°

Figure 11. Surface circulation deduced from recoveries of drift bottles released on Cruise 001-77, January 17-18, 1977.

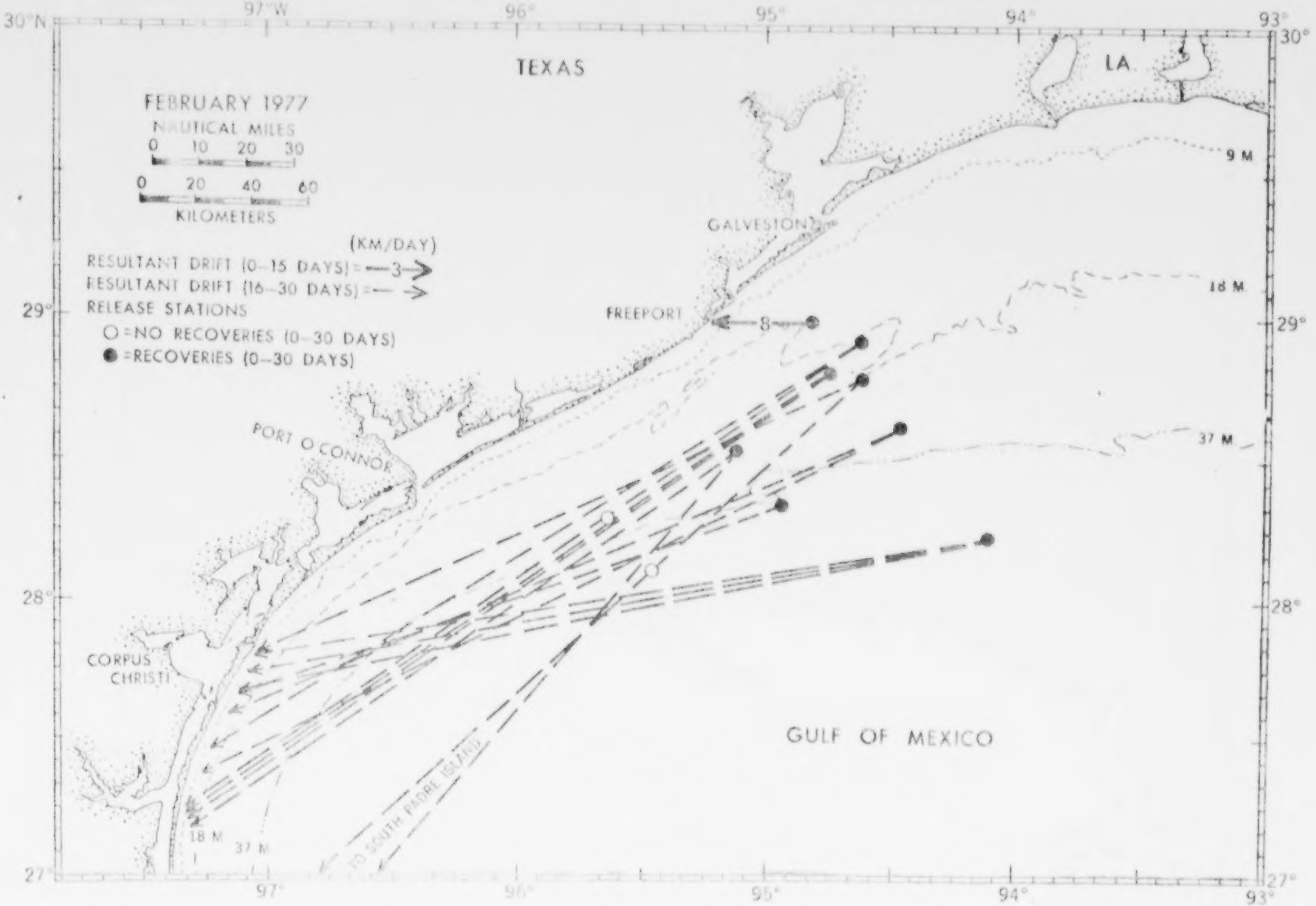

30°N
97°W
96°
95°
94°
93°
30°
TEXAS
LA
FEBRUARY 1977
NAUTICAL MILES
0 10 20 30
0 20 40 60
KILOMETERS
(KM/DAY)
RESULTANT DRIFT (0–15 DAYS) = —3→
RESULTANT DRIFT (16–30 DAYS) = — →
RELEASE STATIONS
○ = NO RECOVERIES (0–30 DAYS)
● = RECOVERIES (0–30 DAYS)
GALVESTON
FREEPORT
8
9 M
18 M
37 M
29°
PORT O'CONNOR
28°
CORPUS CHRISTI
GULF OF MEXICO
TO SOUTH PADRE ISLAND
18 M
37 M
27°
97°
96°
95°
94°
93°
27°

Figure 12. Surface circulation derived from recoveries of drift bottles released on Cruise 003-77, February 18-March 3, 1977.

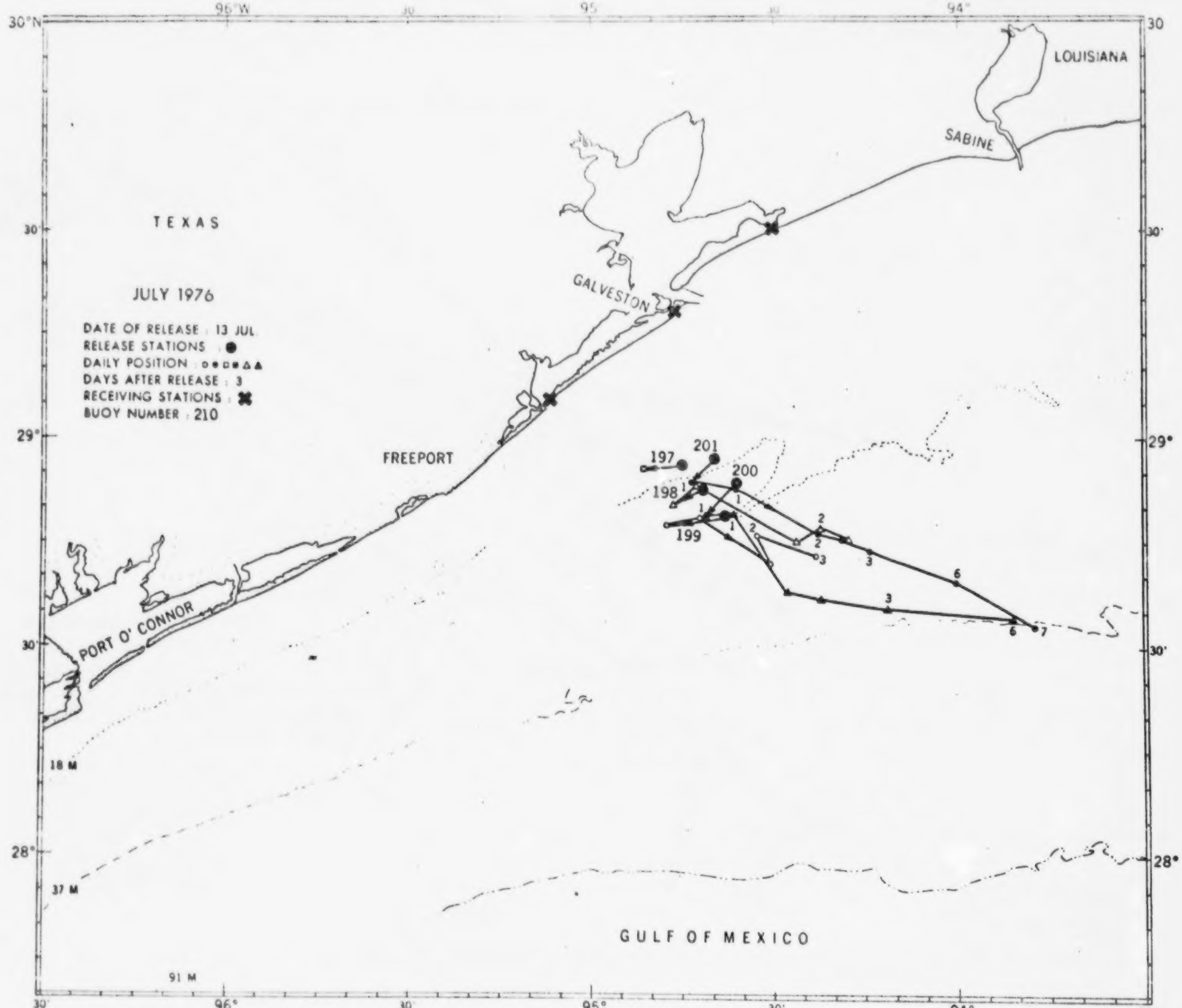
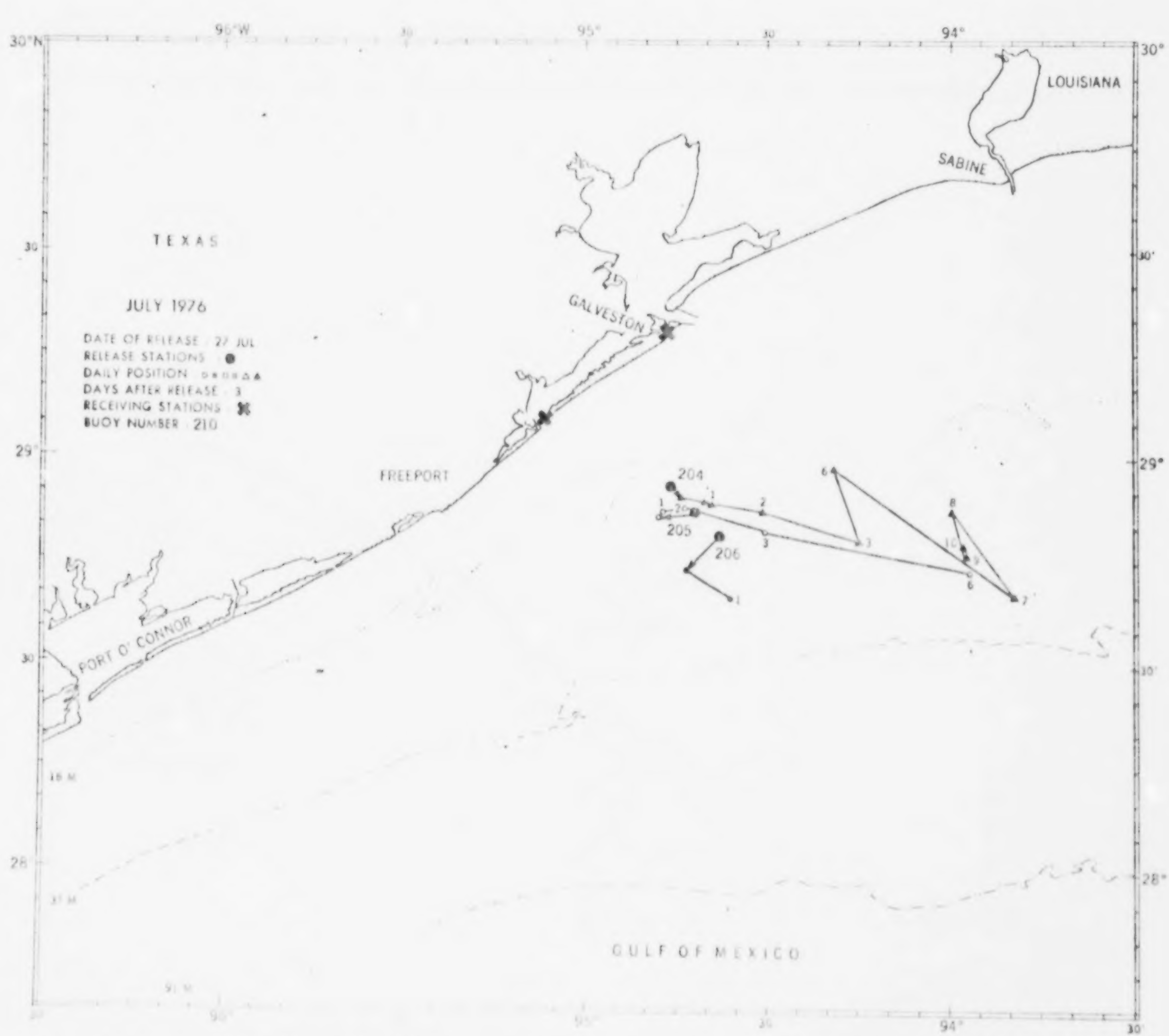

96°W
30
95°
30
94°
30°N
30
29°
30
28°
30
TEXAS
LOUISIANA
SABINE
GALVESTON
FREEPORT
PORT O' CONNOR
GULF OF MEXICO
JULY 1976
DATE OF RELEASE : 13 JUL
RELEASE STATIONS : ●
DAILY POSITION : ○●□■△▲
DAYS AFTER RELEASE : 3
RECEIVING STATIONS : ✖
BUOY NUMBER : 210
197
198
199
200
201
18 M
37 M
91 M

Figure 13. Drift patterns of transponding buoys released on Cruise 005-76, July 13, 1976.



30°N
96°W
30'
95°
30'
94°
30°
TEXAS
LOUISIANA
SABINE
GALVESTON
FREEPORT
PORT O' CONNOR
GULF OF MEXICO
JULY 1976
DATE OF RELEASE : 27 JUL
RELEASE STATIONS : ●
DAILY POSITION : ○●□■△▲
DAYS AFTER RELEASE : 3
RECEIVING STATIONS : ✖
BUOY NUMBER : 210
204
205
206
29°
28°
18 M
37 M
91 M

Figure 14. Drift patterns of transponding buoys released on Cruise 007-76, July 27, 1976.

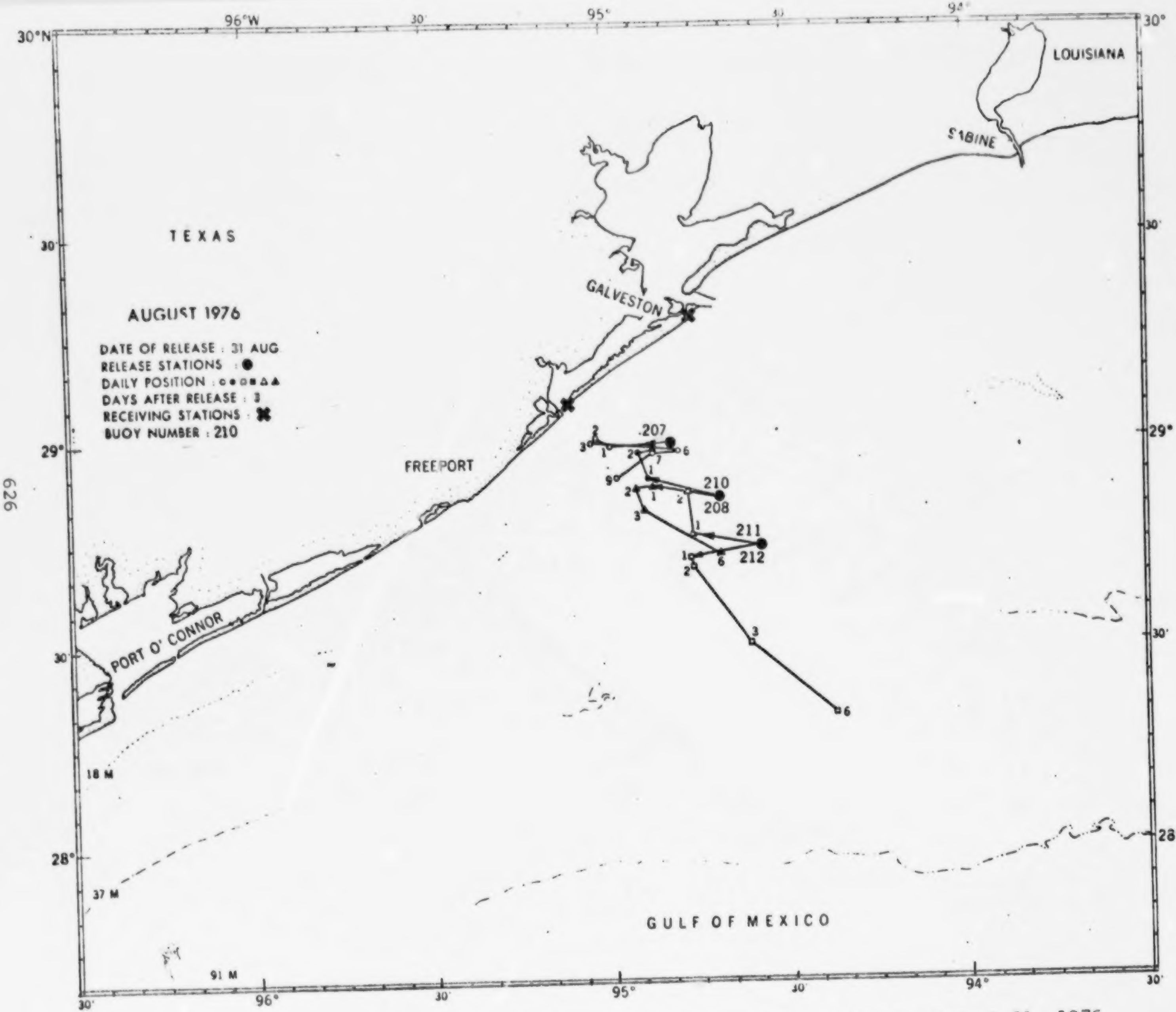

96°W
30'
95°
30'
94°
30°N
30'
29°
30'
28°
30°
30'
29°
30'
28°
30'
96°
30'
95°
30'
94°
30'
TEXAS
LOUISIANA
SABINE
GALVESTON
FREEPORT
PORT O' CONNOR
GULF OF MEXICO
AUGUST 1976
DATE OF RELEASE : 31 AUG
RELEASE STATIONS : ●
DAILY POSITION : ○●□■△▲
DAYS AFTER RELEASE : 3
RECEIVING STATIONS : ✖
BUOY NUMBER : 210
207
210
208
211
212
18 M
37 M
91 M

Figure 15. Drift patterns of transponding buoys released on Cruise 010-76, August 31, 1976.

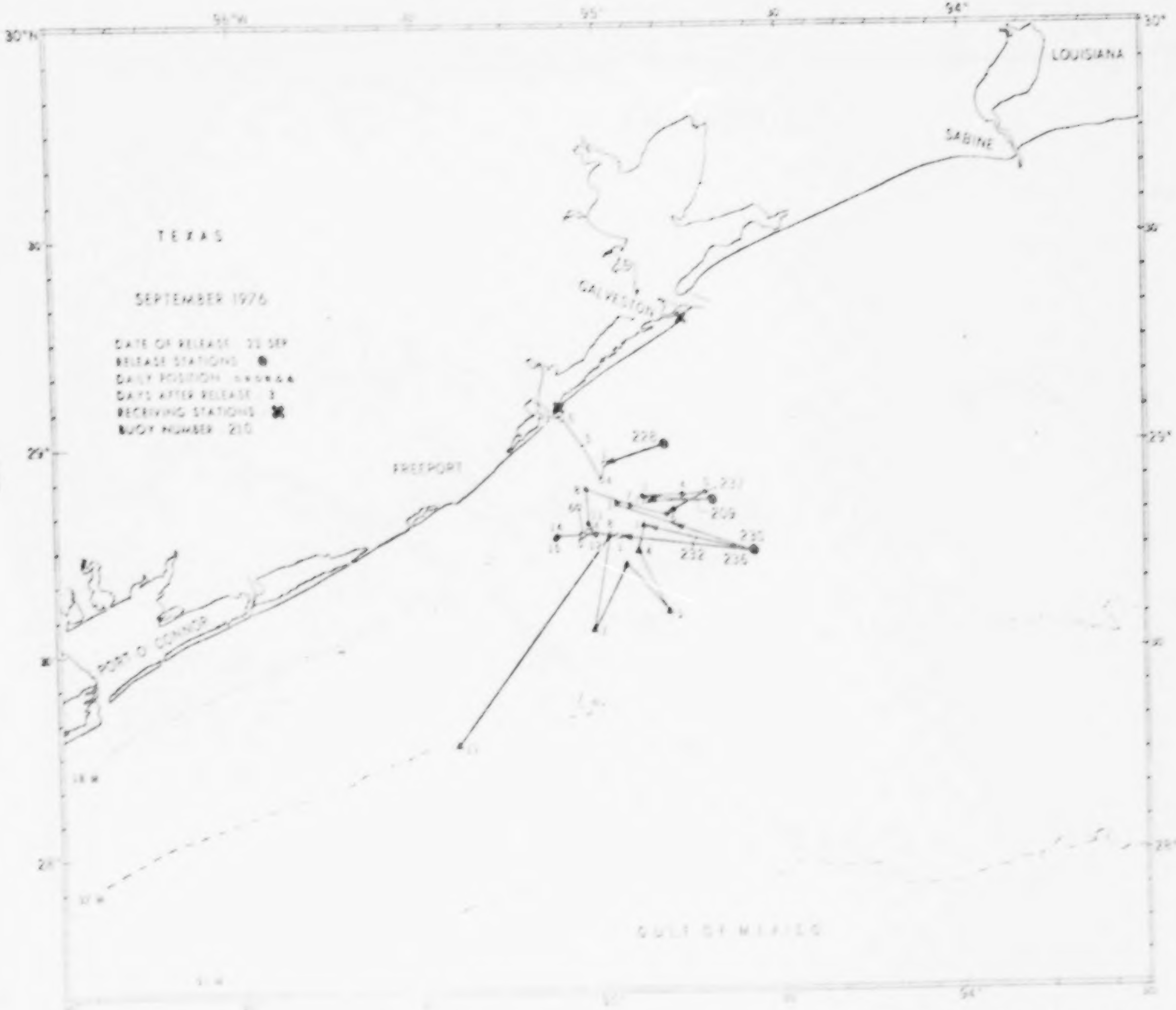

30°N
96°W
95°
30'
94°
30°
LOUISIANA
SABINE
TEXAS
SEPTEMBER 1976
DATE OF RELEASE 23 SEP
RELEASE STATIONS ●
DAILY POSITION
DAYS AFTER RELEASE 3
RECEIVING STATIONS ✖
BUOY NUMBER 210
GALVESTON
FREEPORT
PORT O'CONNOR
228
237
209
235
232
236
29°
28°
GULF OF MEXICO

Figure 26. Drift patterns of transponding buoys released on Cruise 011-76, September 23, 1976.

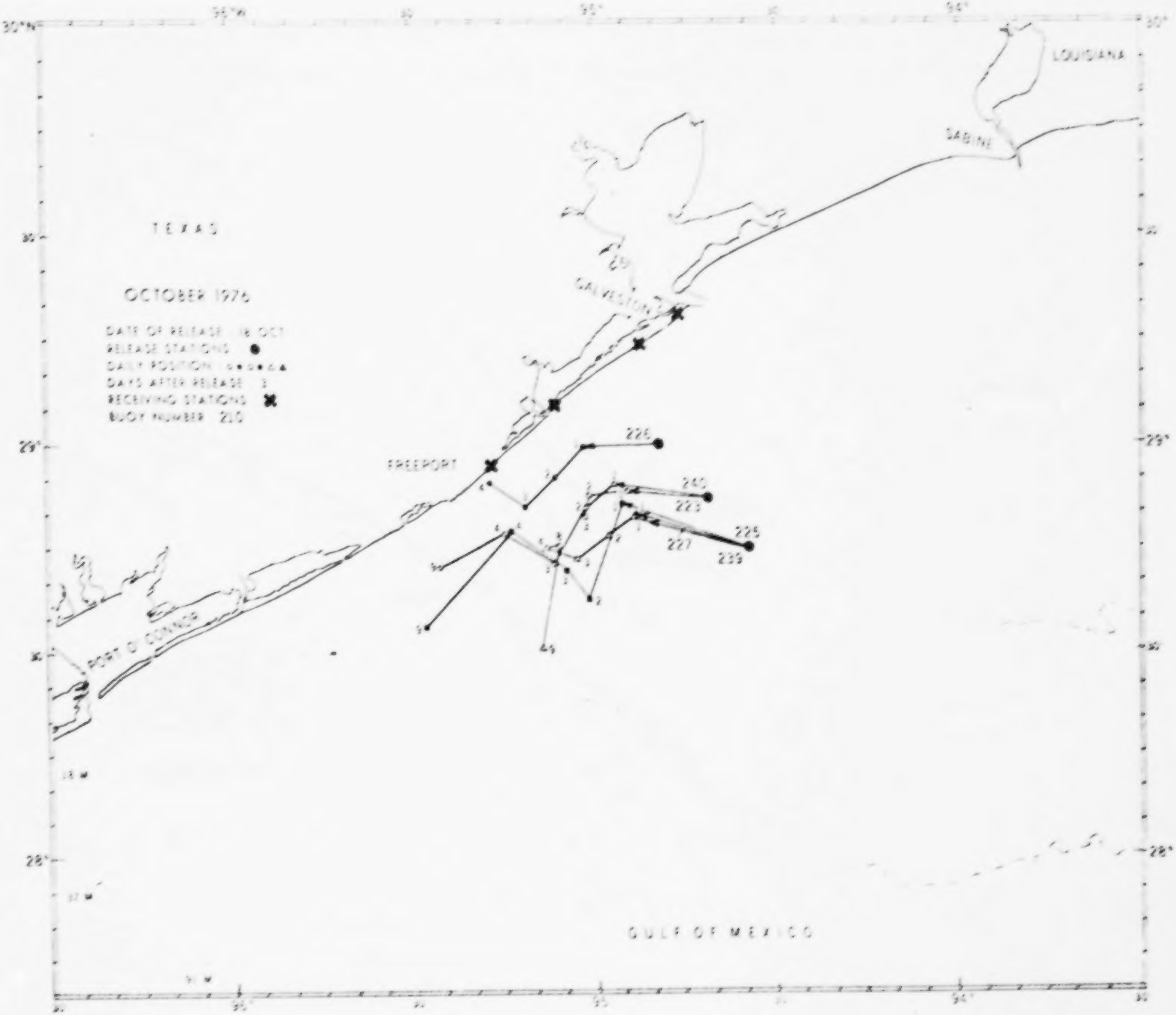

30°N
96°W
30'
95°
30'
94°
30°
29°
28°
LOUISIANA
SABINE
TEXAS
GALVESTON
FREEPORT
PORT O'CONNOR
OCTOBER 1976
DATE OF RELEASE 18 OCT
RELEASE STATIONS ●
DAILY POSITION ● ● ● ● ▲ ▲
DAYS AFTER RELEASE 3
RECEIVING STATIONS ✖
BUOY NUMBER 210
226
240
223
225
227
239
GULF OF MEXICO

Figure 17. Drift patterns of transponding buoys released on Cruise 012-76, October 18, 1976.

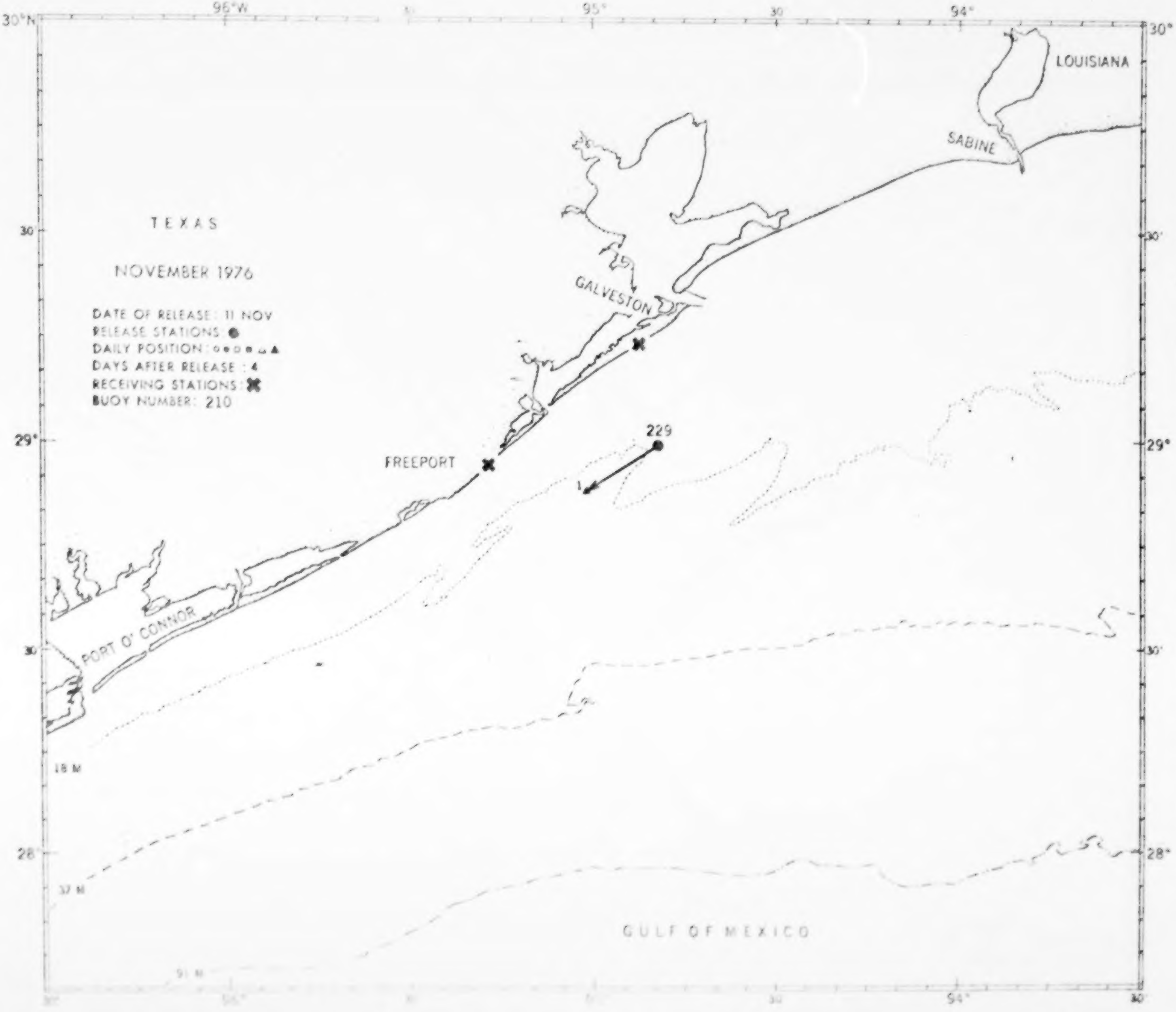

30°N
96°W
95°
30
94°
30°
30'
29°
28°
LOUISIANA
SABINE
TEXAS
NOVEMBER 1976
DATE OF RELEASE: 11 NOV
RELEASE STATIONS: ●
DAILY POSITION: ○ ◐ □ ■ △ ▲
DAYS AFTER RELEASE: 4
RECEIVING STATIONS: ✖
BUOY NUMBER: 210
GALVESTON
FREEPORT
229
PORT O' CONNOR
18 M
37 M
91 M
GULF OF MEXICO

Figure 18. Drift pattern of transponding buoy released on Cruise 013-76, November 11, 1976.

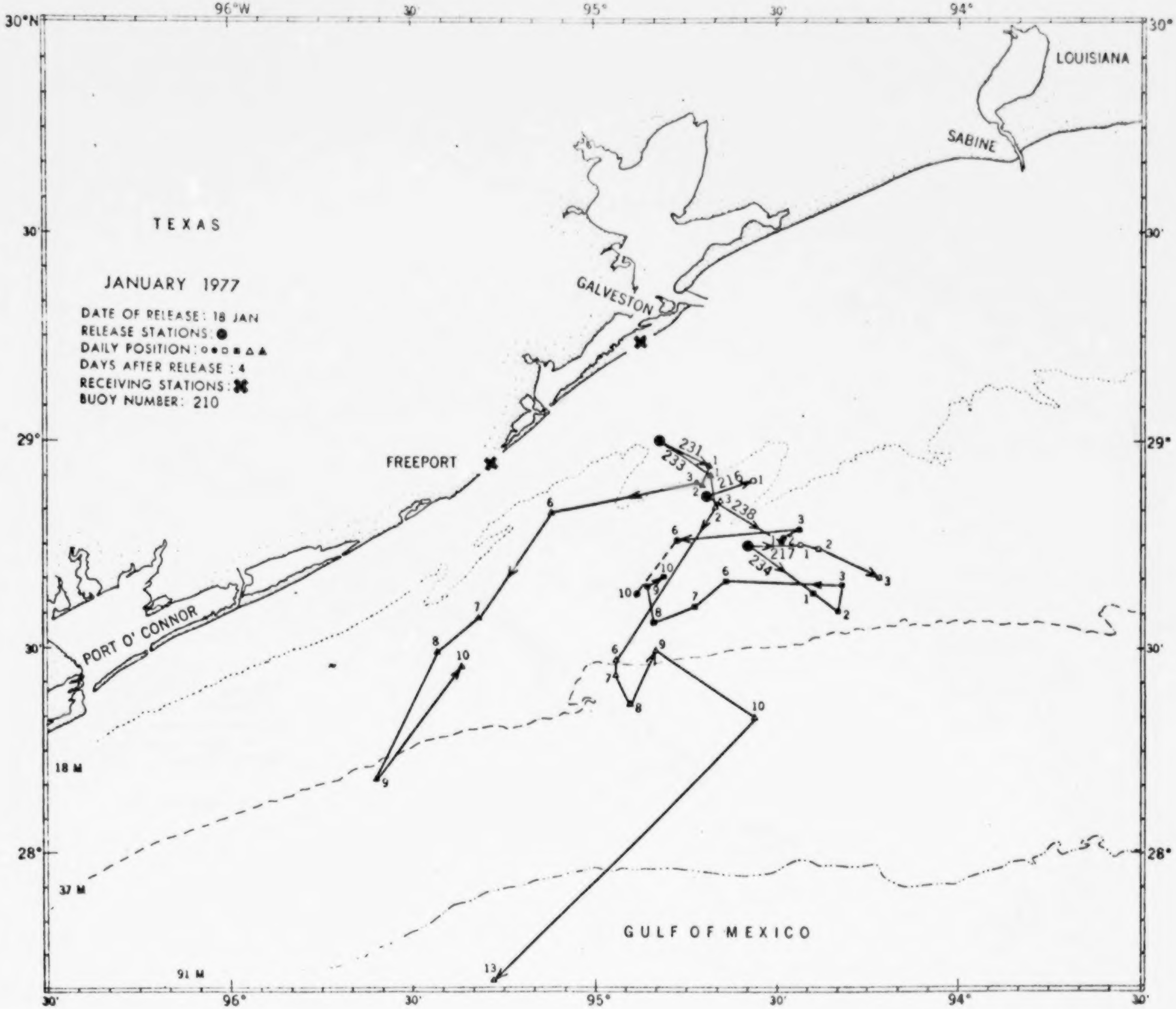

30°N
96°W
30'
95°
30'
94°
30°
TEXAS
LOUISIANA
SABINE
GALVESTON
FREEPORT
PORT O' CONNOR
GULF OF MEXICO
JANUARY 1977
DATE OF RELEASE: 18 JAN
RELEASE STATIONS: ●
DAILY POSITION: ○●◎■△▲
DAYS AFTER RELEASE: 4
RECEIVING STATIONS: ✖
BUOY NUMBER: 210
231
233
216
238
217
234
18 M
37 M
91 M
29°
28°
96°
95°
94°

Figure 19. Drift patterns of transponding buoys released on Cruise 001-77, January 17-18, 1977.

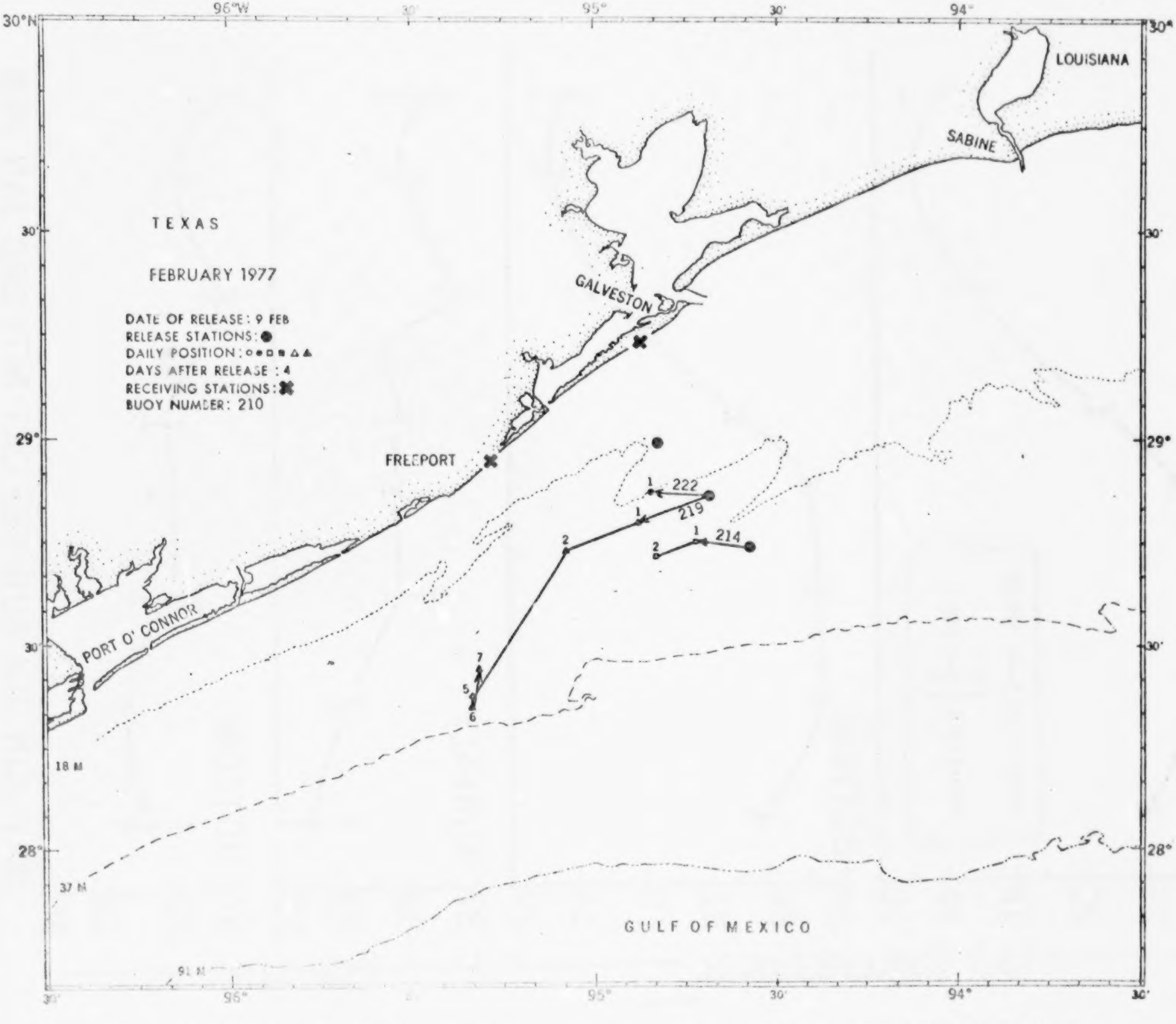

30°N
96°W
30'
95°
30'
94°
30°
LOUISIANA
SABINE
TEXAS
FEBRUARY 1977
DATE OF RELEASE: 9 FEB
RELEASE STATIONS: ●
DAILY POSITION: ○ ● □ ■ △ ▲
DAYS AFTER RELEASE: 4
RECEIVING STATIONS: ✖
BUOY NUMBER: 210
GALVESTON
FREEPORT
PORT O' CONNOR
29°
28°
222
219
214
1
2
5
6
7
18 M
37 M
91 M
GULF OF MEXICO

Figure 20. Drift patterns of transponding buoys released on Cruise 002-77, February 9-10, 1977.

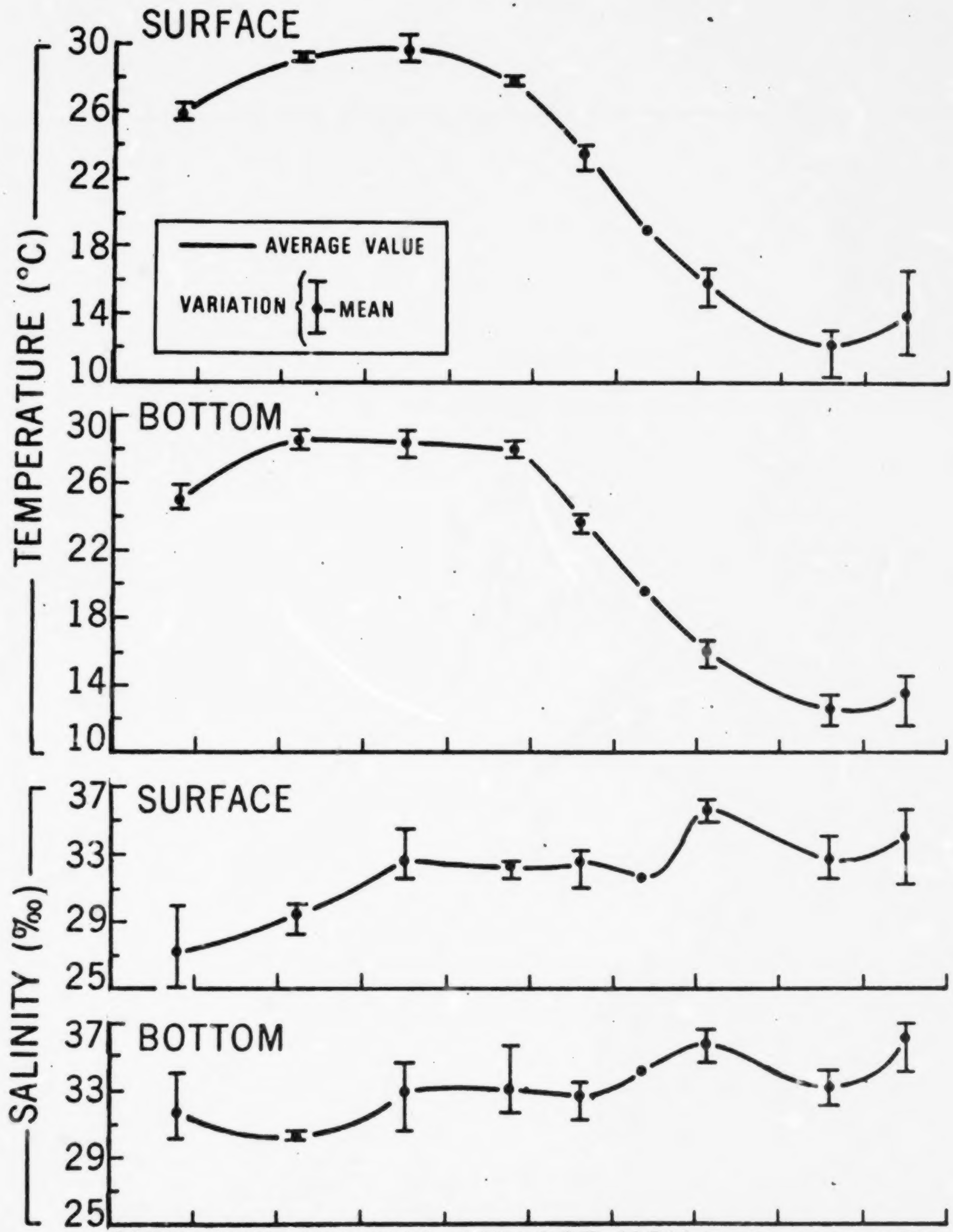


Figure 21. Plots of averaged temperature and salinity values from stations H-1 - H-7 occupied during cruises from May 1976 to February 1977.

HYDROCARBON LEVELS AND PATHWAYS IN THE MAJOR COMPONENTS OF A MARINE ECOSYSTEM

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Houston, Texas 77004

EXECUTIVE SUMMARY

The identities and concentrations of hydrocarbons in crude oil, condensate, discharged brine (formation water), seawater, barnacles, shrimp, squid, plankton, fish, bottom-dwelling organisms, and sediments from the region of the Buccaneer oil field have been determined.

The crude oil contains 18% n-alkanes, together with branched alkanes and aromatic hydrocarbons. The condensate contains a comparable amount of hydrocarbons, but with relatively greater concentrations of the more volatile components. The alkane concentration of the discharged brine ranges up to 9 ppm. There is evidence for petroleum-derived n-alkanes (up to 35 ppb) in surface-seawater samples, but alkanes in bottom-water samples may be of bacterial origin. It is possible, however, that the presence of these bacteria may be due to sulfur discharges from the production platforms. Flesh from sub-surface barnacles is free of petroleum, but there is evidence of petroleum alkanes in some flesh samples of specimens collected at the surface. Most barnacle shell samples (from which attached organisms were not removed) also appeared to contain petroleum-derived alkanes. Of four species of shrimp examined, only one was found to contain petroleum alkanes. Inconclusive results were obtained for plankton, and no petroleum was found in squid or sediments.

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INTRODUCTION

Our objective during the first year of this project was to survey the hydrocarbon content of water, sediments, and biota in the vicinity of the Buccaneer oil field. Extracts from each sample were subjected to column chromatography to obtain "alkane" and "aromatic" fractions, and each was examined by gas chromatography (GC) to determine the amounts of individual compounds. Selected samples were also examined by combined gas chromatography-mass spectrometry (GC-MS) to confirm the identities of such components. The procedures employed were based upon these suggested by the Bureau of Land Management (BLM) for a study of the South Texas Outer Continental Shelf (STOCS). The most significant modification of these procedures was the use of deuteriated internal standards for quantitation (Middleditch and Basile, 1976).

Analyses were performed upon crude oil, condensate, and discharged brine from the two production platforms; surface and bottom water samples collected at distances up to 15 km from the production platforms; sediments; bulk zooplankton obtained at various depths; 25 species of fish (liver and muscle from each); four species of shrimp; the white squid (*Lolliguncula brevis*); and barnacles (*Balanus tintinnabulum*) attached to the production platforms and satellite well jackets. We had intended to examine a variety of bottom-dwelling animals, but were only provided with one brittle worm and a sea urchin. A sample of vessel fuel was also analyzed.

MATERIAL AND METHODS

Materials

All organic solvents (except diethyl ether) were Mallinckrodt "nanograde" quality. Silica gel (60-200 mesh) for chromatography, obtained from J. T. Baker Chemical Co., was heated at 170° for at least 24 hours before use. Hydrocarbon standards were purchased from Applied Science Laboratories Inc. or from Chem Service Inc., and deuteriated hydrocarbons from Merck and Co.

Apparatus

Gas chromatography was performed on Perkin Elmer 3920B instruments equipped with flame ionization detectors and temperature programmers. 2m x 6mm silanized glass columns were packed with 1% OV-1 on Supelcoport (100-120 mesh) and were programmed from 100 to 300° at 4° per min. The injector and detector temperatures were, respectively, 225 and 300°.

For GC-MS, a Hewlett-Packard 5982A instrument was used under similar conditions, except that the column temperature was limited to 270° since the instrument was equipped with silicone membrane molecular separator. The instrument was interfaced to a Hewlett-Packard 5933A dual disc interactive data system with a Tektronix 4012 graphic display terminal and a Tektronix 4631 hard copy unit. Spectra were acquired and stored every 2 sec. through a chromatogram and programs were available for a full range of data manipulation procedures.

Tissue samples were homogenized using a Brinkmann PT 10-35 Polytron power unit and a PT 20ST generator.

A Buchi/Brinkman Rotavapor R rotating evaporator was employed for reducing solvent volumes.

Some samples were freeze-dried using a lyophilizer manufactured by New Brunswick Scientific Co.

METHODS

Use of internal standards. Deuteriated hydrocarbons were added to all samples prior to analysis so that quantitative data would not be impaired by variations in sample recovery, GC injection volume, or instrument parameters. The compounds employed were n-eicosane-D42, n-dotriacontane-D66, pyrene-D10, and 1,2-benzanthracene-D12 (Fig. 1). An appropriate quantity of the mixture of deuteriated hydrocarbons was added to each sample before analysis. For example 2 µl of a 0.1% solution added to 1 liter of sea water afforded a concentration of 2 ppb. The deuteriated alkanes were separated from alkanes on a normal packed GC column (Fig. 2), so no mass spectrometer was required for their selective detection.

Extraction of crude oil. Small samples (1 µl, approx, 1 mg) of each sample were shaken with 1 ml of cyclohexane. The volumes were reduced by evaporation under nitrogen, and the concentrated solutions were fractionated by column chromatography.

Extraction of condensate. This was performed in the same manner as for crude oil.

Extraction of discharged brine. 0.2-1.0 liter was used for analysis. Hydrochloric acid was added to adjust the brine to pH 2. 100 ml of the brine was shaken with 100 ml of cyclohexane. The aqueous layer was discarded and the same 100 ml of cyclohexane was shaken with a further 100 ml of brine. This procedure was repeated until the entire brine sample had been extracted. In principle, it would have been more efficient to extract the brine sample several times with larger volumes of cyclohexane but this might have led to greater contamination of the sample. Any possible reduction in recovery of hydrocarbons from the brine was offset by similar losses of the deuteriated hydrocarbons, so the results of the analyses were unimpaired. The extracts were reduced in volume using the Rotavapor prior to column chromatography.

Extraction of seawater. This was performed in the same manner as for discharged brine.

Extraction of sediments. Approximately 100 g of sediment was transferred to a 300 ml lyophilization flask (Virtis F-121) and was freeze-dried. The dried sample was then transferred to a 45 x 130 mm glass extraction thimble in a modified soxhlet apparatus (Toe-Pre 807). The sample was extracted with cyclohexane (300 ml) for 6 hr. and the extract was reduced in volume prior to chromatography.

Extraction of fish, zooplankton, shrimp, squid, and bottom-dwelling organisms. Approximately 10-40 g of tissue from each type of animal was homogenized using the Polytron unit and then heated with 4 M sodium hydroxide solution (4 ml) at 90° for 2 hrs. The saponified material was extracted twice with 15 ml aliquots of diethyl ether and, each time, the supernatant was drawn off after centrifugation at 2000 rpm for 10 min. The combined extracts were dried over anhydrous sodium sulfate and evaporated using the Rotavapor prior to chromatography.

Extraction of barnacles. The barnacles grow in clusters, which were broken up using degreased pliers. The shells were broken open to remove the flesh, which was extracted in the same manner as for other biota. The shells were extracted (without freeze-drying) in a manner similar to that for the sediments.

Column chromatography. Isolation of the "alkane" and "aromatic" fractions was effected using a column of silica gel. The dry powder was poured to a depth of 20 cm in a 1 cm x 40 cm glass column fitted with a coarse sintered glass disc and a Teflon stopcock at the lower end, and a 100 ml reservoir and a ground glass joint at the upper end. Cyclohexane was poured into the column and forced through the packing at a slight excess pressure using nitrogen, to remove air bubbles. A total of 100 ml of cyclohexane was used to wash the column. The sample was applied to the top of the column in a small volume of solvent. The "alkane" fraction was eluted with cyclohexane (40 ml) and the "aromatic" fraction with benzene (40 ml). Some lipid-rich samples, particularly biota, overloaded the column, and lipids eluted in these fractions. In such cases, indicated by a yellow coloration of the "alkane" fraction or anomalous GC peaks, column chromatography of these fractions was repeated.

Gas chromatography. "Alkane" and "aromatic" fractions were examined separately, but under similar conditions. 4 μl (10% or more of the total extract) was injected into the instrument. A major advantage of the use of internal standards is that the proportion injected does not have to be determined precisely: the ratio of sample to standard is constant. [A Perkin-Elmer 4900B autosampler was purchased to assist in this work, so that GC runs could be performed overnight with the instrument unattended. Because of mechanical defects in the accessory this aim was never achieved and the unit has been returned to the manufacturer.]

Gas chromatography - mass spectrometry. Selected samples were further analyzed to verify the identities of components.

Quality control. Strenuous efforts were made to minimize contamination of the samples, which would yield erroneous results. Periodically, "blank" analyses were performed, and washing from sample bottles before use (to check contamination) and after use (to check on recovery) were examined.

RESULTS AND INTERPRETATION

The "alkane" and "aromatic" fractions of each sample were examined by gas chromatography. Analytical data for the "alkane" fractions are tabulated in the appendix in the same format as the Pilot Study (Giam, 1976) for ease of comparison. This is the same format used in the BLM STOCS Study.

Each category of sample is tabulated separately, and each sample within a category is assigned a Roman number. We intend to retain this system in subsequent reports for ease of comparison of data.

With the exception of the first day of the first sediment-collection cruise (6-5-76) we did not participate in the actual sample collections. Samples were collected for us by several persons, and a variety of code numbers have been used to describe their locations. For each category of sample we have indicated the positions of these locations. Readers should note, in particular, that the alphanumeric codes assigned to water samples collected at MARMAP locations are unrelated to those used in the Buccaneer oil field study.

We have included in the tabulations data which are tentatively ascribed to n-alkanes but which may actually be other compounds. They have been deleted in such cases where we have obtained mass spectrometric evidence for their identities, but have otherwise been retained. The most notable examples are di-n-butyl phthalate (a ubiquitous plasticizer) which elutes from the gas chromatograph with n-pentacosane, and squalene which coelutes with n-octacosane.

PLATFORM SAMPLES

A network of pipelines carries the gas/oil/brine mixture from the satellite wells to the production platforms. The gas is easily separated from the liquids, but some of the heavier components of the gas later condense. The crude oil is separated from the brine by settling, and the polished brine is discharged into the sea. We have examined crude oil, condensate, and discharged brine samples from each of the two production platforms.

The compositions of the crude oil and condensate samples are unremarkable.

Discharged brine is apparently the major source of pollution in the oilfield. The sample collected from platform A on April 21 contained a relatively high concentration of n-alkanes (1.5 ppm in the range C-12 to C-30) with a typical petroleum-like profile. A number of aromatic hydrocarbons have been identified in the "aromatic" fraction of this sample, including (in decreasing order of concentration) ethylbenzene, a methylethylbenzene, naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, an ethylnaphthalene, styrene, and a methylvinylnaphthalene. This fraction was also found to contain a relatively high concentration of squalene, an indication of the existence of microorganisms in the brine separator. [Since reporting this observation, we have learned that bacterial growth is evident in the brine separators, and is controlled by bactericides.]

Other brine samples from platform A, collected on December 17, January 30, and February 1 contained, respectively, 136, 260, and 567 ppb of n-alkanes. An additional sample collected on December 17 contained no sulfur and only 17 ppb of n-alkanes; it was probably an effluent sample from the desalinization plant on the platform.

Brine samples from platform B, collected between July 16 and February 1, contain 0 to 527 ppb of n-alkanes. The sample containing no detectable n-alkanes, collected on September 25, did contain sulfur.

On March 8, several brine collections were made at both platforms. Four samples from platform A, collected at hourly intervals, contained 293-776 ppb of n-alkanes, while samples from platform B contained 4.69 to 8.78 ppm of n-alkanes. The samples from platform A were collected at 30°C and exhibited maximum n-alkane concentrations between n-tetradecane and n-nonadecane, whereas samples from platform B, collected at 20.6° C, had maximum n-alkane concentrations between n-dodecane and n-pentadecane. Presumably, the elevated temperatures at platform A led to differential evaporation of the lighter n-alkanes.

WATER SAMPLES

On June 5, samples were taken by divers below the outfall pipe at Platform A. n-Alkane concentrations were highest at the surface (11.9 ppb). In each sample, the pristane/n-heptadecane and phytane/n-octadecane ratios were about 0.81 and 0.27 respectively. These ratios approximate those (0.76, 0.23) in the brine sample collected from platform A on April 21. The surface water sample (I) exhibits a typical "petroleum" distribution with concentration of n-alkanes decreasing of with chain length. This trend is less pronounced in the mid-depth (II) and bottom (III) water samples. There are lower relative amounts of the lighter alkanes, leading to a maximum concentration at around n-hexadecane. The hydrocarbons in the region C-12 to C-24 are, however, clearly of petroleum origin.

Several water samples (IV/XII) were collected at random locations between June 5 and July 2. Total n-alkane levels ranged from 0.7 ppb (VII) to 24.8 ppb (X). The highest level was found in a surface water sample collected 50 m east of well 10, where a pipeline leak was suspected. There is no clear evidence that the hydrocarbons in this sample are petroleum derived: no pristane or phytane was detected and the hydrocarbons in the region C-26 to C-36 are probably of bacterial origin (see below). Some general observations may be made concerning the data obtained from other samples collected during this period. The surface water samples (IV, VIII, IX) clearly contain petroleum-derived n-alkanes, with maximum concentrations around n-octadecane. The bottom water samples do not contain such compounds but do contain a group of n-alkanes with maximum concentrations around n-dotriacontane, which are probably of bacterial origin. Where samples were taken both near the surface and bottom (VIII, IX, XI, XII) total n-alkane concentrations were much greater in the latter. Small amounts of heavier n-alkanes C-39 to C-37: maximum, C-31) are observed in surface water samples indicating that they also contain some hydrocarbons of bacterial origin.

It became apparent that little meaningful data concerning the hydrocarbon centration gradients throughout the study could be obtained by continued random sampling, so a sample collection cruise was made from one end of the study area to the other (SW to NE) on August 31 and September 1 (samples XIII to XXXXIV). Both surface and bottom water samples were collected at each of 11 locations. These data are shown in Figs. 4 and 5, in addition to being listed in Table 5. Several trends in these data can be discerned. Surface water n-alkane concentrations are greater in the X and Y control areas (29.7 and 35.3 ppb, respectively) than at the center of the oilfield (4.6-9.2 ppb). This was contrary to expectation, but may merely reflect variation in the concentration of hydrocarbons in the discharged brine. The surface water n-alkanes exhibit a concentration maximum ar around eicosane (Fig. 6) and have pristane/heptadecane (0.63-1.00; mean, 9.72) and phytane/octadecane (0.44-0.52, mean 0.48) ratios comparable to those in the brine samples. The surface water n-alkanes, then, can confidently be classified as petroleum-derived, but it should be noted that these samples also contain smaller amounts of n-alkanes of apparent bacterial origin, with concentration maxima around n-dotriacontane (Fig. 6). The type and distribution of n-alkanes in bottom water samples is somewhat different. To the Southwest of the oilfield, total n-alkane concentrations range from 7.7 to 23.1 ppb, whereas to the Northeast they are only 1.2-3.7 ppb (Fig. 5). A bimodal distribution of n-alkane chain lengths (Fig. 6) is most apparent in the Southwest sector (Fig. 7). The major components, around n-tritriacontane are apparently of bacterial origin, whereas those around n-eicosane exhibit the distribution characteristic of petroleum hydrocarbons. It should be noted that the highest concentrations of n-alkanes in the bottom water samples are apparently downstream in the bottom-current flowing through the oilfield (Martin, 1976).

Data pertaining to the samples collected on August 31 and September 1 clearly indicated that the influence of the oilfield is more extensive than first assumed, and that the location of the X and Y control areas is inappropriate. Additional samples (XXXV-XLIV) were therefore collected at MARMAP sample sites as much as 10 nautical miles from the center of the oilfield, on September 23. None of these samples contained more than 1 ppb of total hydrocarbons. Interestingly, the sample collected from the center of the oilfield (XXXVIII) contained only 25 ppt each of two compounds.

Thirty-two additional water samples were collected, between December 3 and March 2. Eight of these samples contained no detectable n-alkanes. The only sample containing more than 5 ppb of n-alkanes (LVIII, 10.8 ppb) was apparently not contaminated with petroleum. In sample LXVII, the alkanes n-pentadecane to n-tricosane exhibited a petroleum-like profile, but their concentration amounted only to 0.7 ppb. Even the sample collected adjacent to platform B on March 2 contained only 20 ppt each of n-hexadecane, n-octadecane, and n-eicosane, and 40 ppt of n-heptadecane.

BARNACLE SAMPLES

Separate analyses were perfomred upon the flesh and shells. While most of the flesh was removed from the shells, no attempt was made to remove vegetation.

Twenty-four of the twenty-eight shell samples contained petroleum-like n-alkanes, usually ranging from n-docosane to n-triacontane or n-tetratriacontane, with maximum concentrations at n-pentacosane. It is not possible at this time to rule out a bacterial origin for these n-alkanes. It is also possible that they derive from attached sponges. Further work is required to clarify the origin of these hydrocarbons.

Sixteen of the seventeen flesh samples collected at depths of 7.5 to 15 m did not contain petroleum-like n-alkanes. A possible exception is sample XI in which 8.6% of the n-alkanes (those between C-22 and C-27) may be of petroleum origin. A striking feature of the flesh samples from barnacles collected at the surface is that five of the eleven samples apparently contained petroleum hydrocarbons. One might expect such a finding since petroleum hydrocarbons tend to float at the air-sea interface, but we feel that further work is required to rule out a bacterial origin for these hydrocarbons.

SHRIMP AND SQUID SAMPLES

Four species of shrimp and one species of squid were examined. One of the three brown shrimp (*Penaeus aztecus*) (III) contained a large amount (2.45 ppm) of petroleum-like n-alkanes in the region n-eicosane to n-triacontane. A second specimen (IV) contained only 110 ppb of n-alkanes but these, too, were petroleum-like. In comparison, a third specimen contained 240 ppb of n-alkanes, none of which appeared to be petroleum-derived.

No petroleum hydrocarbons were observed in the other species of shrimp or the squid.

PLANKTON SAMPLES

No attempt was made to separate or identify individual species of plankton. However, Dr. N. Fotheringham has identified the major species as the sergestid shrimp (*Lucifer faxoni*), a chaetognath (*Sagitta tenuis*), and a copepod (*Acartia tonsa*). [See also Fotheringham and Brunenmeister (1975).]

The first eight samples, collected by bongo net, afforded tentative evidence for petroleum-like n-alkanes in the C-16 to C-21 region. This was most pronounced in sample VII. In the other seven samples however, this observation may be due merely to the presence of relatively large amounts of n-heptadecane of biogenic origin.

It was thought that plankton dwelling at the surface, and most exposed to petroleum, would contain more petroleum-derived hydrocarbons, so eight additional samples (IX XVI) were collected by neuston net. Again, one might suggest that the C-16 to C-21 n-alkanes are petroleum-derived but, in samples XI to XIV, there was clearer evidence for petroleum-derived n-alkanes in the region between n-eicosane and n-triacontane, with maximum concentrations around n-hexacosane. Sample XIV was notable in that it contained 3.36 ppm of n-alkanes, with n-heptadecane (usually the most abundant biogenic n-alkane) accounting for only 1.2% of this amount.

Some of the n-alkanes in sample XVIII, collected near the center of the oilfield, may also have been petroleum-derived.

FISH SAMPLES

Twenty-five species of fish were examined. Muscle tissue from each species was analyzed and, if sufficient material was available, the liver was also analyzed. We had intended to analyze the gonads, but they were too small.

Archosargus probatocephalus (sheepshead). Three specimens were examined. Petroleum hydrocarbons were found in muscle tissue from the first two specimens (LX, LXII), but not the third (LXIV). Curiously, these alkanes were present in liver from the third specimen (LXV), but not the first two (LXI, LXIII).

Arius felis (sea catfish). Two specimens were examined. Muscle samples contained 295 (XXVII) and 367 (XXXIII) ppb of alkanes. The major alkanes were n-heptadecane, and pristane, and there were no petroleum alkanes. The livers contained 3.2 (XXVIII) and 0.78 (XXXIV) ppb of alkanes. n-Heneicosane predominated. It is possible that the C-23 and C-30 alkanes (0.38 ppm) in sample XXXIV were petroleum-derived.

Centropristis philadelphica (rock seabass). Muscle tissue (XXXIX) contained only n-hexadecane (25 ppb) and n-heptadecane (150 ppb), while no alkanes were detected in the liver (XL).

Chaetodipterus faber (atlantic spadefish). Both the muscle (LVI, 1.6 ppm alkanes) and liver (LVII, 2.8 ppm) were dominated by pristane (1.22 and 1.26 ppm, respectively), and there was also a relatively large amount (0.9 ppm) of n-heneicosane in the liver. The C-21 to C-28 alkanes in muscle (70 ppb) and C-22 to C-27 alkanes in liver (280 ppb) may have been petroleum-derived.

Citharichthys spilopterus (bay whiff). The muscle sample (L) analyzed contained only 51 ppb, but the C-22 and C-31 alkanes (42 ppm) exhibited the characteristic petroleum-like distribution. The liver was not examined.

Cyonoscion arenarius (sand seatrout). Three specimens were analyzed. There was little pristane in muscle from the first two samples (I, 20 ppb; XV, 40 ppb), the major alkanes being n-pentadecane and n-heptadecane. Muscle from the third specimen, (XXIX) however, contained 16 ppm of pristane. This sample also contained n-hentriacontane (100 ppb). There was no clear evidence for petroleum contamination in any of these samples. Livers from the first two samples contained onl6 2.28 (II) and 2.71 (XVI) ppm, but the third (XXX) contained 542 ppm of alkanes. The C-27 to C-31 alkanes in sample XXX (490 ppm) were probably petroleum-derived.

Diplectrum bivittatum (dwarf sand perch). The muscle (XLI) and liver (XLII) contained, respectively, 140 ppb and 1 ppm of biogenic alkanes.

Lutjanus campechanus (red snapper). Two specimens were examined. Muscle tissue contained 750 (V) or 160 (XIII) ppb of biogenic alkanes, principally n-pentadecane, n-heptadecane, and pristane. Liver tissue contained 4.5 (VI) or 1.2 (XIV) ppm of alkanes and, again, there was no evidence of petroleum contamination.

Menticirrhus americanus (southern kingfish). The muscle (VII) and liver (VIII) tissue contained 275 ppb and 1.5 ppm, respectively, of alkanes. The C-22 to C-26 alkanes may have been petroleum-derived.

Micropogon undulatus (atlantic croaker). Muscle from two specimens and a liver from one of them were examined. Muscle from the first sample (XXVI) contained 120 ppb of biogenic alkanes, whereas muscle from the second specimen (XLV) contained only petroleum-like alkanes (C-24 to C-28, 25 ppb). Liver from the second sample (XLVI) contained 790 ppb of alkanes of which 550 ppb (C-22 to C-30) may be petroleum-derived.

Ogcocephalus parvus (roughback batfish). The muscle (XXXV) contained 70 ppb and the liver (XXXVI) contained 1.6 ppm of n-alkanes. There was no clear evidence of petroleum contamination.

Opsanus pardus (leopard toadfish). The muscle tissue (LVIII) contained 66 ppb of alkanes, of which 24 ppb (C-23 to C-27) may be petroleum-derived. The liver (LIX) contained 860 ppb of alkanes, probably biogenic and dominated by pristane (430 ppb).

Orthopristis chrysoptera (pigfish). Two specimens were examined. Muscle from the first (XLIII) contained only 90 ppb of alkanes, and these compounds were absent from muscle of the second (LIV). Liver from the first (XLIV) contained only n-pentacosane (670 ppb) and n-heptacosane (840 ppb), while liver from the second (LV) contained 2.2 ppm of C-25 to C-31 alkanes.

Peprilus burti (gulf butterfish). The muscle tissue (XLVII) contained 1.75 ppm of alkanes, principally pristane, n-pentadecane, and n-nonadecane.

There were no petroleum-derived alkanes. The liver was not examined.

Pomatomus saltatrix (bluefish). Two specimens were examined. Muscle from the first (XXII) contained 616 ppb of alkanes, principally n-pentadecane and n-heptadecane. The C-21 and C-35 alkanes (207 ppb) exhibited a typical petroleum-like distribution. The second sample (XXIV; total alkanes, 1.9 ppm) contained much more n-heptadecane (1.3 ppm) but the C-22 to C-35 alkanes (190 ppb) were also petroleum derived. Similar alkane distributions were observed in the livers. 180 ppb (C-20 to C-30) of the 520 ppb of alkanes in the first specimen (XXIII) were petroleum-derived, as were 350 ppb (C-22 to C-27) of the 2.8 ppm of alkanes from the second sample (XXV).

Porichthys porosissimus (atlantic midshipman). The muscle (XX) contained 1.6 ppm of biogenic n-alkanes, principally n-pentadecane, pristane, and n-heptadecane. The liver (XXI; total alkanes, 23 ppm) also contained large amounts of n-heptadecane and n-pentadecane, but the C-21 to C-27 alkanes (10 ppm) were petroleum-derived.

Prionotus ophryas (bandtail searobin). The muscle tissue (XLIX) contained only 30 ppb of C-15 to C-18 alkanes. The liver was not examined.

Prionotus rubio (blackfin searobin). Two specimens were analyzed. Muscle from the first (III) contained only 100 ppb of biogenic alkanes, whereas muscle from the second (XVII) contained 3.8 ppm of alkanes. The C-23 to C-27 alkanes (230 ppb) may have been petroleum-derived. Liver from the first (IV) contained only n-heneicosane (300 ppb) whereas that from the second (XVIII) contained 22 ppm of alkanes, dominated by n-pentadecane. There was no clear evidence for petroleum contamination.

Saurida brasiliensis (largescale lizardfish). The major alkanes from muscle of this specimen (XXXI; total alkanes, 170 ppb) were n-pentadecane and n-heptadecane, but C-22 to C-30 petroleum alkanes were present to the extent of 81 ppb. The liver (XXXII) contained 24 ppm of alkanes, dominated by n-pentadecane and pristane. There was no evidence for petroleum contamination.

Scorpaena calcarata (smoothead scorpionfish). The muscle (XLVIII) contained 80 ppb of biogenic alkanes, and the liver was not examined.

Stenotomus caprinus (longspine porgy). The muscle (XIX) contained 840 ppb of alkanes, mainly pristane, n-pentadecane, and n-heptadecane. The C-21 to C-25 alkanes (90 ppb) may be petroleum-derived. The liver was not analyzed.

Syacium papillosum (dusky flounder). All of the alkanes (C-20 to C-31) in the muscle (LI) are probably petroleum-derived (67 ppb). It is also likely that the C-23 to C-31 alkanes (180 ppb) in the liver (LII; total alkanes, 330 ppb) are from petroleum.

Symphurus plagiusa (blackcheek tonguefish). The muscle (LIII; total alkanes, 960 ppb) from this specimen was heavily contaminated with petroleum alkanes. It is probably that most, if not all, of the n-alkanes (840 ppb) were petroleum-derived. The liver was not examined.

Synodus foetens (inshore lizardfish). Two specimens were examined. The muscle samples (IX, XI) contained 1.4 and 2.5 ppm, respectively, of n-alkanes, principally n-pentadecane, n-heptadecane, and pristane. The C-20 to C-27 alkanes of the first sample (120 ppb) exhibited the typical petroleum-like distribution. Muscle from the second specimen was uncontaminated. Liver samples (X, XII) contained 140 ppb and 1.3 ppm, respectively, of n-alkanes, dominated by n-pentadecane. There was no clear evidence for petroleum contamination in the livers of either specimen.

Urophycis floridanus (southern hake). It is possible that the C-24 to C-26 alkanes (25 ppb) in the muscle (XXXVII; total alkanes, 75 ppb) were petroleum-derived. There is clearer evidence that the C-22 to C-28 alkanes (120 ppb) in the liver (XXXVIII; total alkanes, 170 ppb) resulted from petroleum contamination.

There was good evidence for petroleum alkanes in *A. probatocephalus*, *C. spilopterus*, *C. arenarius*, *M. undulatus*, *P. saltatrix*, *P. porosissimus*, *P. rubio*, *S. brasiliensis*, *S. caprinus*, *S. papillosum*, *S. plagiusa*, *S. foetens*, and *U. floridanus*. It was also possible that *A. felis*, *C. faber*, and *O. pardus* were contaminated, but there were no petroleum alkanes in the other nine species examined. Levels of petroleum alkanes were usually higher in livers than in muscle tissue.

BENTHIC ORGANISMS

With the exception of the barnacles, the other biota examined are free-swimming and one cannot be certain that they are permanent residents of the oil-field. We had hoped to examine a large number of bottom-dwelling organisms, which would be more likely to concentrate petroleum hydrocarbons. However, we were supplied only with a brittle worm and a sea urchin, neither of which contained petroleum hydrocarbons.

SEDIMENT SAMPLES

All of the sediment samples described in this report were collected in the period June 5-12, 1976. n-Alkanes were found in concentrations ranging from 30 ppb (XV) to 3.15 ppm (XXXVI). There are no clearly sample II, Tables 6 to 8). Visual inspection of the n-alkane distribution reveals a smooth profile, relative concentration decreasing with chain length. The calculated OEP value, (0.82), however, is considerably less than 1.00, reflecting the predominance of n-dodecane. If the calculation is performed on n-alkanes in the C-13 to C-30 range, an OEP value of 1.27 is obtained, which might lead one to conclude that the n-alkanes are of biogenic origin. Pending the development of a statistical test of "smoothness" of profile, we prefer to rely upon visual inspection of the data. It should be noted that there may be lesser amounts of the lighter n-alkanes in some samples: they may be lost by preferential evaporation, solubility, metabolism, etc. Consequently, a concentration maximum for n-alkanes in the C-12 to C-25 region is indicative of petroleum-derived hydrocarbons. We have followed tradition in tabulating OEP values in the Appendix, but we feel that they are of little value.

Recognition of bacterial n-alkanes is less difficult than it might be assumed. Bacteria associated with petroleum production contain n-alkanes in the C-25 to C-35 region (Davis, 1968). The co-existence of petroleum-derived and biogenic n-alkanes in some of the water samples is clearly discerned from the bimodal n-alkane profiles. Some sponges and corals also contain C-25 to C-35 n-alkanes with no odd-carbon preference (Koons *et al.*, 1965).

It has been suggested that measurements of n-alkane/isoprenoid alkane ratios be used to determine the origin of marine hydrocarbon pollutants (Ehrhardt and Blumer, 1972). Ratios of pristane/n-heptadecane and phytane/n-octadecane are frequently reported. These ratios are of great value in determining the origins of crude oil samples in slicks, but are of limited utility when trace amounts of petroleum hydrocarbons are encountered in the presence of biogenic hydrocarbons: some organisms contain high concentrations of isoprenoid hydrocarbons and some contain none. We have tabulated such ratios in the Appendix, but feel that they are of little value.

Brine samples. The discharged brine contains branched and n-alkanes, aromatic hydrocarbons, and squalene. All compounds except squalene are petroleum-derived. Visible amounts of elemental sulfur were present in most samples of discharged brine. The flame ionization detectors in our gas chromatographs do not respond to sulfur, which coelutes with n-octadecane, but the identity of this substance was confirmed by GC-MS.

Squalene is of particular sifnificance since it is a metabolic intermediate in the biosynthesis of sterols by most animals and plants. Thus, organisms are apparently living in the somewhat hostile environment of the brine separation tanks. Bacteria are generally considered unable to biosynthesize sterols (Lehninger, 1975), but we have previously shown that the methane-utilizing bacteria Methylococcus capsulatus produces both squalene and sterols (Bird *et al.*, 1971). We recommend that a search be made for hydrocarbon-utilizing bacteria in the discharged brine and that a sufficient quantity be isolated for hydrocarbon analysis.

Water samples. As might be expected, since oil floats on water, we found ample evidence for petroleum-derived hydrocarbons, both near the production platforms and some distance from them. The unusual distribution of the compounds on August 31 and September 1 was ascribed to variations in the hydrocarbon content of the discharge brine. It was assumed that a relatively high rate of discharge was followed by a period of reduced hydrocarbon discharge prior to sample collection. Before this suggestion can be confirmed, additional data are required concerning the variations in hydrocarbon content of discharged brine and the rate of dispersion of hydrocarbons at the air-sea interface.

We have suggested that the heavier n-alkanes found in the bottom water samples down-current from the oilfield are of bacterial origin. The bimodal n-alkane profiles certainly suggest that they have an origin independent of that of the petroleum hydrocarbons, and their composition is typical of sulfur-utilizing bacteria. This information, together with our knowledge of sulfur discharge from the production platforms, leads us to suggest that a fluctuating bacterial plume extends Southwest from the oilfield.

Barnacle samples. n-Alkanes found in these samples may be petroleum derived. It is possible that those from the shells are from attached sponges (Koons *et al.*, 1965). It is also possible that they are of bacterial origin. It is of interest that flesh samples from about half of the surface specimens also contain such hydrocarbons, whereas flesh from most of the submerged specimens do not. Specimens collected from a semi-submerged wreck, for example, could be of value in determining the origins of these hydrocarbons.

Shrimp and squid samples. Two specimens of brown shrimp contain n-alkanes analogous to those found in the barnacles. To resolve the origin of these hydrocarbons, it may be useful to examine specimens grown under rigidly controlled conditions in mariculture.

CONCLUSIONS

This has been a year of exploration. Others have determined the identities of the biota and the nature of the sediments; we have determined the classes and amounts of hydrocarbons in each of these and in the water. The data acquired during this year should provide a firm foundation for subsequent studies of a more specific nature.

We recommend that the following additional studies be performed:

Additional screening studies. Hydrocarbon analyses for additional species of bottom-dwelling organisms and plants. Brine samples should be examined at regular intervals.

Hydrocarbon plume delineation. Determination of the extent of detectable hydrocarbons in the water, in the vicinity of the brine discharges. This work may be aided by the use of a colored dye.

Plankton studies. Hydrocarbon analyses of individual species of phytoplankton and zooplankton.

Bacteria. Hydrocarbon analyses of cultured bacteria should clarify the nature of heavier n-alkanes in bottom water samples and of n-alkanes in barnacles and shrimp.

Modeling. A formal model of the inputs, fates, and effects of hydrocarbons in the study area should be constructed, based upon data obtained during this study and additional published information.

LITERATURE CITED

Bird, C. W., J. M. Lynch, F. J. Pirt, W. W. Reid, C. J. W. Brooks, and B. S. Middleditch, "Steroids and squalene in *Methylococcus capsulatus* grown on methane," *Nature*, *230*, 473 (1971).

Davis J. B., "Paraffinic hydrocarbons in the sulfate-reducing bacterium *Desulfovibrio desulfuricans*," *Chem. Geol.*, *3*, 155-160 (1968).

Ehrhardt, M. and M. Blumer, "The source identification of marine hydrocarbons by gas chromatography," *Environ. Polut.*, *3*, 179-194 (1972).

Fotheringham, N. and S. Brunenmeister, "Common Marine Invertebrates of the Northwestern Gulf Coast," Gulf Publishing Company, Houston (1975).

Giam, C. S., "A preliminary environmental assessment of the Buccaneer oil/gas field. IV. Levels of Petroleum hydrocarbons in sediments, Buccaneer oil field," in "Pilot Study of the Buccaneer Oil Field (Benthos and Sediments)," Gulf Fisheries Center, Galveston, pp. 44-51 (1976).

Harper, D. E., "A preliminary environmental assessment of the Buccaneer oil/gas field. I. Introduction, field methods and abiotic characteristics of the study area," in "Pilot Study of the Buccaneer Oil Field (Benthos and Sediments)," Gulf Fisheries Center, Galveston, pp. 1-8 (1976).

Koons, C. B., G. W. Jamieson, and L. S. Ciereszko, "Normal alkane distribution in marine organisms: possible significance to petroleum origin," *Bull. Amer. Assoc. Petroleum Geologists*, *49*, 301-304 (1965).

Lehninger, A. L., "Biochemistry," Worth Publishers, Inc., New York, 2nd edition, p. 298 (1975).

Martin, J., "Hydrography," presented at Meeting of Principal Investigators, EPA Buccaneer Oil Field Study, October 6, 1976, Galveston.

Middleditch, B. S. and B. Basile, "Deuteriated analogs as internal standards for the quantitation of environmental alkanes by gas chromatography," *Analyt. Letters*, *9*, 1031-1034 (1976).

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APPENDIX

Table 1.

TABULATION OF PLATFORM SAMPLES

Sample	Date	Platform*	Description
I	4-21-76	A	crude oil
II	4-21-76	A	condensate
III	4-21-76	A	discharged brine
IV	7-16-76	B	crude oil
V	7-16-76	B	condensate
VI	7-16-76	B	discharged brine
VII	9-25-76	B	discharged brine
VIII	10-30-76	B	discharged brine
IX	12-17-76	A	discharged brine
X	12-17-76	A	discharged brine
XI	12-17-76	B	discharged brine
XII	01-30-77	A	discharged brine
XIII	01-30-77	B	discharged brine
XIV	02-01-77	A	discharged brine
XV	02-01-77	B	discharged brine
XVI	03-08-77	B	discharged brine (1300)
XVII	03-08-77	B	discharged brine (1400)
XVIII	03-08-77	B	discharged brine (1500)
XIX	03-08-77	B	discharged brine (1600)
XX	03-08-77	A	discharged brine (1415)
XXI	03-08-77	A	discharged brine (1515)
XXII	03-08-77	A	discharged brine (1615)
XXIII	03-08-77	A	discharged brine (1715)

*See Figure 8.

TABLE 2.

DISTRIBUTION OF n-ALKANES IN PLATFORM SAMPLES

Sample	I	II	III	IV	V	VI	VII
C-12	1.3	27.3	19.9	14.5	50.4	0.9	0
C-13	1.7	21.2	14.7	13.3	25.2	6.0	
C-14	3.8	16.8	12.8	12.3	13.0	11.2	
C-15	20.7	14.7	11.6	12.3	6.5	13.8	
C-16	17.2	9.6	8.8	10.3	3.1	12.1	
C-17	12.1	5.4	6.9	7.6	1.2	10.3	
C-18	9.7	2.9	4.8	6.1	0.5	8.6	
C-19	8.2	1.4	4.1	5.6	0.2	6.0	
C-20	6.0	0.5	3.3	4.2	0.1	5.2	
C-21	4.6	0.2	2.7	3.3	4.3		
C-22	3.7	0.1	2.2	2.7	3.4		
C-23	3.0		1.9	2.1	3.4		
C-24	2.3		1.4	1.6	1.7		
C-25	1.8		1.4	1.3	1.7		
C-26	1.2		0.9	0.9	3.4		
C-27	0.9		0.8	0.7	1.7		
C-28	0.6		0.7	0.4	1.7		
C-29	0.5		0.7	0.3	1.7		
C-30	0.3		0.5	0.2	0.9		
C-31	0.2			0.1	0.9		
C-32	0.2			0.1	0.9		
C-33	0.1			0.1			
C-34	0.1						
C-35							
C-36							
C-37							

TABLE 2. (continued)

Sample	VIII	IX	X	XI	XII	XIII	XIV
C-12							
C-13			8.1	10.6		6.3	
C-14		1.5	12.5	16.7	5.4	12.5	
C-15	12.3	1.5	14.0	16.3	8.1	12.5	
C-16	23.4	5.9	14.0	13.9	11.5	18.8	1.8
C-17	18.3	11.8	12.5	10.6	14.2	31.3	9.2
C-18	12.9	17.6	9.6	8.0	13.1		12.7
C-19	10.2	11.8	7.4	6.1	13.1	6.3	15.9
C-20	6.6	17.6	5.9	4.7	9.6	12.5	14.1
C-21	4.8	2.9	3.7	3.2	8.1		12.4
C-22	3.6	5.9	2.9	2.7	6.5		10.6
C-23	2.4		2.2	1.9	4.6		8.8
C-24	1.5	2.9	1.5	1.3	2.7		7.1
C-25	1.5	2.9	1.5	0.9	1.9		4.4
C-26	0.9	5.9	1.1	0.9	1.2		1.8
C-27	0.6	1.5	0.4	0.4			0.9
C-28	0.3			0.4			0.4
C-29	0.3	1.5		0.2			
C-30	0.1	1.5	0.4	0.2			
C-31	0.1	1.5	0.2	0.2			
C-32	0.1	1.5	0.2	0.4			
C-33		1.5	0.7	0.1			
C-34		2.9	0.4	0.2			
C-35							
C-36							
C-37							

TABLE 2. (continued)

Sample	XV	XVI	XVII	XVIII	XIX	XX	XXI
C-12			21.6		9.3		
C-13		27.8	21.6	26.6	10.2	1.0	0.9
C-14	17.8	16.7	12.3	22.8	20.8	3.1	2.6
C-15	18.3	15.6	11.7	13.6	22.2	5.2	8.7
C-16	15.3	11.5	9.0	10.3	10.0	8.2	15.7
C-17	12.8	8.5	6.8	7.8	7.6	12.4	19.1
C-18	9.3	5.8	4.7	5.4	5.5	13.4	14.8
C-19	7.8	4.3	3.8	4.2	4.4	14.4	12.2
C-20	5.3	3.0	2.5	2.8	3.0	12.4	8.7
C-21	4.0	2.2	1.8	2.0	2.2	10.3	6.1
C-22	3.3	1.6	1.4	1.4	1.6	8.2	4.3
C-23	2.3	1.2	1.1	1.1	1.2	5.2	3.5
C-24	1.5	0.8	0.7	0.7	0.8	3.1	1.7
C-25	1.3	0.6	0.5	0.5	0.5	2.1	1.3
C-26	0.8	0.3	0.3	0.3	0.3	1.0	0.4
C-27	0.3	0.1	0.1	0.4	0.1		
C-28					0.1		
C-29							
C-30							
C-31							
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 2. (continued)

Sample	XXII	XXIII
C-12		
C-13	6.6	7.9
C-14	11.1	10.5
C-15	17.5	10.5
C-16	18.0	7.9
C-17	13.4	7.9
C-18	10.1	5.3
C-19	8.0	5.3
C-20	5.3	5.3
C-21	3.4	7.9
C-22	2.1	7.9
C-23	1.3	10.5
C-24	0.7	5.3
C-25	0.3	5.3
C-26	0.1	2.6
C-27		
C-28		
C-29		
C-30		
C-31		
C-32		
C-33		
C-34		
C-35		
C-36		
C-37		

TABLE 3.

ADDITIONAL ANALYTICAL DATA FOR PLATFORM SAMPLES

Sample	Total n-Alkanes	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	18.6%	1.05	0.32	1.16
II	17.1%	0.87	0.24	0.75
III	1.5 ppm	0.76	0.23	0.82
IV	18.0%	1.12	0.41	0.88
V	10.8%	0.77	0.30	0.49
VI	58.0 ppb	0.80	0.30	1.01
VII	0	-	-	-
VIII	334 ppb	0.77	0.26	1.02
IX	17.0 ppb	1.00	0.33	0.58
X	136 ppb	0.82	0.31	1.06
XI	527 ppb	0.80	0.24	1.03
XII	260 ppb	0.95	0.41	1.00
XIII	16 ppb	-	-	1.28
XIV	567 ppb	1.00	0.49	1.06
XV	398 ppb	0.94	0.43	0.88
XVI	8.78 ppm	0.83	0.28	1.52
XVII	5.09 ppm	0.84	0.27	0.90
XVIII	4.69 ppm	0.81	0.27	1.29
XIX	6.25 ppm	0.88	0.28	0.95
XX	776 ppb	0.92	0.31	1.02
XXI	460 ppb	0.82	0.35	1.07
XXII	754 ppb	0.86	0.32	1.11
XXIII	293 ppb	1.00	1.00	1.23

TABLE 4.

TABULATION OF WATER SAMPLES

Sample	Date	Location*	Depth	Collection Method
I	6-5-76	Pfm. A	surface	diver
II	6-5-76	Pfm. A	mid-depth	diver
III	6-5-76	Pfm. A	bottom	diver
IV	6-5-76	Sta. 105	surface	bucket
V	6-6-76	Sta. 108	bottom	nansen
VI	6-11-76	Sta. 70	bottom	nansen
VII	6-11-76	Sta. 76	bottom	nansen
VIII	7-1-76	Sta. 9	surface	bucket
IX	7-1-76	Sta. 9	bottom	nansen
X	7-1-76	Jkt. 10	unknown	unknown
XI	7-2-76	Sta. 104	surface	bucket
XII	7-2-76	Sta. 104	bottom	nansen
XIII	8-31-76	Loc. 1	surface	bucket
XIV	8-31-76	Loc. 1	bottom	nansen
XV	8-31-76	Loc. 2	surface	bucket
XVI	8-31-76	Loc. 2	bottom	nansen
XVII	8-31-76	Loc. 3	surface	bucket
XVIII	8-31-76	Loc. 3	bottom	nansen
XIX	8-31-76	Loc. 4	surface	bucket
XX	8-31-76	Loc. 4	bottom	nansen
XXI	9-1-76	Loc. 5	surface	bucket
XXII	9-1-76	Loc. 5	bottom	nansen
XXIII	9-1-76	Loc. 6	surface	bucket
XXIV	9-1-76	Loc. 6	bottom	nansen
XXV	9-1-76	Loc. 7	surface	bucket
XXVI	9-1-76	Loc. 7	bottom	nansen
XXVII	9-1-76	Loc. 8	surface	bucket
XXVIII	9-1-76	Loc. 8	bottom	nansen
XXIX	9-1-76	Loc. 9	surface	bucket
XXX	9-1-76	Loc. 9	bottom	nansen
XXXI	9-1-76	Loc. 10	surface	bucket
XXXII	9-1-76	Loc. 10	bottom	nansen
XXXIII	9-1-76	Loc. 11	surface	bucket
XXXIV	9-1-76	Loc. 11	bottom	nansen
XXXV	9-23-76	H-1	surface	bucket
XXXVI	9-23-76	H-1	bottom	nansen
XXXVII	9-23-76	H-3	surface	bucket
XXXVIII	9-23-76	H-3	bottom	nansen
XXXIX	9-23-76	H-5	surface	bucket
XL	9-23-76	H-5	bottom	nansen

TABLE 4. (continued)

Sample	Date	Location*	Depth	Collection Method
XLI	9-23-76	H-6	surface	bucket
XLII	9-23-76	H-6	bottom	nansen
XLIII	9-23-76	H-7	surface	bucket
XLIV	9-23-76	H-7	bottom	nansen
XLV	12-3-76	H-2	surface	nansen
XLVI	12-3-76	H-2	bottom	nansen
XLVII	12-3-76	H-4	surface	nansen
XLVIII	12-3-76	H-4	bottom	nansen
XLIX	12-3-76	H-5	surface	nansen
L	12-3-76	H-5	bottom	nansen
LI	12-3-76	H-6	surface	nansen
LII	12-3-76	H-6	bottom	nansen
LIII	12-3-76	B	surface	nansen
LIV	12-3-76	B	bottom	nansen
LV	12-3-76	C	surface	nansen
LVI	12-3-76	C	bottom	nansen
LVII	12-3-76	F	surface	nansen
LVIII	12-3-76	G	surface	nansen
LIX	12-3-76	G	bottom	nansen
LX	12-17-76	1-1	surface	bottle
LXI	12-17-76	1-2	surface	bottle
LXII	12-17-76	1-3	surface	bottle
LXIII	12-17-76	1-3	surface	bottle
LXIV	12-17-76	1-5	surface	bottle
LXV	12-17-76	2-1	surface	bottle
LXVI	12-17-76	2-2	surface	bottle
LXVII	12-17-76	2-3	surface	bottle
LXVIII	12-17-76	2-4	surface	bottle
LXIX	2-15-77	X	surface	bucket
LXX	2-15-77	X	bottom	nansen
LXXI	2-16-77	P	surface	bucket
LXXII	2-16-77	P	bottom	nansen
LXXIII	2-17-77	Y	surface	bucket
LXXIV	2-17-77	Y	bottom	nansen
LXXV	3-2-77	Jkt. N	surface	bottle (diver)
LXXVI	3-2-77	Pfm. B	surface	bottle (diver)

*See Figures 3, 4, 5, 8, and 9.

TABLE 5.

DISTRIBUTION OF n-ALKANES IN WATER SAMPLES

Sample	I	II	III	IV	V	VI	VII
C-12	18.6	0.6	2.8	1.1			
C-13	13.5	0.3	5.7	0.5			
C-14	11.8	2.0	2.6	0.5			
C-15	11.0	2.3	3.0	1.1			
C-16	11.0	2.9	4.2	2.2	2.7		
C-17	8.4	2.9	3.2	7.6	2.7		
C-18	7.6	2.2	3.4	13.0			
C-19	4.2	1.7	1.9	17.3			
C-20	3.4	0.7	1.9	14.1	2.7		
C-21	2.5	0.9	1.1	7.6	2.7		
C-22		1.5	1.1	3.2	5.4		
C-23			1.1	1.1	2.7		
C-24	1.3	0.9	1.3	1.1	5.4		3.6
C-25			4.0		32.4	21.1	10.7
C-26			1.9	3.2	5.4	4.8	3.6
C-27		1.5	2.6		5.4	7.7	10.7
C-28		9.3	3.4		10.8	7.7	10.7
C-29		4.1	3.8	1.1	2.7	2.4	3.6
C-30	2.5	10.5	6.6	4.3	2.7	2.4	3.6
C-31		5.8	7.5	5.4	2.7	2.4	3.6
C-32	1.7	13.7	14.2	3.2	2.7	21.4	28.6
C-33	0.8	9.9	7.0	3.2	5.4	15.3	21.4
C-34	0.4	8.1	5.7	2.2	2.7	15.3	
C-35	0.4	5.8	4.0	1.6	2.7		
C-36	0.8	4.7	2.6	2.2			
C-37							

TABLE 5. (continued)

Sample	VIII	IX	X	XI	XII	XIII	XIV
C-12							
C-13							
C-14	3.4						
C-15	7.9	0.7	2.4	0.9		0.3	0.2
C-16	9.9	0.7	2.4	3.6		2.1	0.4
C-17	12.8	0.7	16.1	8.1		18.4	0.9
C-18	6.4	0.7	2.4	5.4		16.4	0.9
C-19	3.4	0.7	2.4	6.3		23.2	1.7
C-20	3.4	0.4	0.8	2.7		17.8	1.7
C-21	1.5	0.4	1.6	2.7		10.2	0.9
C-22	1.5	0.4	2.4	3.6		5.4	0.4
C-23	1.5	0.4	2.4	5.4		2.3	
C-24	1.5	0.4	2.4	3.6		1.1	0.4
C-25	3.4	0.7	6.5	11.7	19.0	0.8	0.6
C-26	2.0	1.4	4.0	3.6		0.6	0.9
C-27	6.4	2.8	4.0	4.5	9.5	0.1	1.7
C-28	11.3	7.0	7.3	9.0	19.0	0.3	3.9
C-29	2.0	9.8	4.0	3.6	9.5		4.8
C-30	4.9	11.2	5.6	3.6	9.5		8.7
C-31	4.9	15.4	9.7	6.3	9.5	0.2	15.6
C-32	4.9	14.0	7.3	5.4	9.5	0.1	16.5
C-33	3.4	11.2	6.5	3.6	9.5	0.1	18.6
C-34	2.0	7.0	4.0	3.6	4.8	0.2	11.7
C-35	1.5	4.9	3.2	2.7		0.1	9.5
C-36		7.0	2.4				
C-37		2.1					

TABLE 5. (continued)

Sample	XV	XVI	XVII	XVIII	XIX	XX	XXI
C-12							
C-13							
C-14							
C-15				0.8	1.1	0.7	2.2
C-16	0.5	1.3		1.2	3.2	0.7	6.6
C-17	3.3	1.3	3.7	1.4	8.9	1.4	13.2
C-18	9.9	3.9	10.6	2.3	15.6	1.8	13.7
C-19	20.3	7.7	21.2	2.3	22.0	2.1	15.4
C-20	21.7	7.2	24.3	2.3	20.6	2.1	13.7
C-21	16.5	3.9	16.9	1.2	12.8	1.1	8.8
C-22	9.4	2.6	10.6	0.6	7.1	0.7	4.4
C-23	5.2	1.3	5.3	0.6	3.2	0.4	2.2
C-24	2.8	0.7	2.6	0.6	1.8	0.4	2.2
C-25	2.8	3.9	1.1	0.6	1.8	1.1	2.2
C-26	0.9	1.3	0.5	0.6	0.7	0.7	2.2
C-27	0.9	1.3	0.5	0.8	0.4	1.4	2.2
C-28	1.4	3.3	0.5	2.9	0.2	1.8	2.2
C-29	1.9	3.9	0.5	4.6	0.2	4.3	2.2
C-30	0.5	5.9	0.5	7.8	0.2	7.8	1.1
C-31	0.5	10.5	0.5	13.9	0.2	13.8	1.1
C-32	0.5	10.5	0.5	13.9		15.6	1.1
C-33	0.5	11.8		16.2		16.7	1.1
C-34	0.5	7.8		9.8		10.3	1.1
C-35		5.2		8.1		7.9	1.1
C-36		3.3		7.0		4.6	1.1
C-37		2.0		2.9			

TABLE 5. (continued)

Sample	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVIII
C-12							
C-13							
C-14							
C-15			4.3		7.7		
C-16	0.6		8.7		15.4		
C-17	0.6	4.2	4.3	15.2	7.7	7.0	50.0
C-18	0.6	10.6	8.7	14.1	7.7	15.8	16.6
C-19	0.6	19.0	8.7	21.7	7.7	22.8	16.6
C-20	0.8	19.0	8.7	19.6	7.7	19.3	
C-21	0.6	14.1	4.3	11.9	3.8	12.3	
C-22	0.3	7.7	4.3	6.5	3.8	7.0	16.6
C-23	0.3	4.2	2.2	3.3	3.8	3.5	
C-24	0.6	2.1	4.3	2.2	3.8	1.8	
C-25	0.6	2.8	8.7	1.1	3.8	1.8	
C-26	1.1	1.4	4.3	1.1	3.8	1.8	
C-27	1.1	1.4	4.3	1.1	7.7	1.8	
C-28	3.4	2.8	4.3	1.1	3.8	1.8	
C-29	5.1	0.7	4.3	1.1	3.8	1.8	
C-30	8.5	0.7	4.3			0.9	
C-31	15.3	0.7	4.3		3.8	0.9	
C-32	15.3	0.7	2.2		3.8		
C-33	17.6	1.4	2.2				
C-34	10.8	1.4	2.2				
C-35	7.9	1.4					
C-36	5.1	2.1					
C-37	3.4	1.4					

TABLE 5. (continued)

Sample	XXIX	XXX	XXXI	XXXII	XXXIII	XXXIV	XXXV
C-12							
C-13							
C-14					2.2		
C-15	0.8	3.0	1.7	5.4	5.0	1.5	
C-16	2.4	9.1	3.4	5.4	8.6	1.5	16.7
C-17	6.3	6.1	6.8	8.1	11.5	1.5	16.7
C-18	12.6	6.1	10.2	5.4	11.8		
C-19	22.0	12.1	14.7	5.4	13.6	2.4	
C-20	20.5	15.2	13.6	5.4	11.5	2.4	
C-21	12.6	6.1	7.9	2.7	6.8	1.5	
C-22	6.3	3.0	5.1	5.4	5.0	3.0	
C-23	3.1	3.0	2.8	5.4	4.3	3.0	
C-24	1.6	3.0	2.3	2.7	3.2	3.0	
C-25	2.4	3.0	3.4		3.6	6.5	
C-26	0.8	3.0	1.7	2.7	2.5	3.6	16.7
C-27	0.8	3.0	2.3	8.1	1.8	5.9	16.7
C-28		3.0	3.4	5.4	2.9	8.9	16.7
C-29		3.0	2.8	2.7	2.2	5.9	16.7
C-30		3.0	2.8	5.4	1.8	6.5	
C-31		3.0	4.0	8.1	2.5	11.8	
C-32	7.9	3.0	4.0	5.4	2.2	8.9	
C-33			2.8	5.4	1.8	8.9	
C-34			1.7	2.7	0.7	5.9	
C-35			1.7		0.7	3.0	
C-36			1.1		0.4	4.1	
C-37							

TABLE 5. (continued)

Sample	XXXVI	XXXVII	XXXVIII	XXXIX	XL	XLI	XLII
C-12							
C-13							
C-14							
C-15		4.8			14.5		
C-16	8.3	9.5		12.5	28.9	3.4	44.4
C-17	16.7	19.0		25.0	14.5	21.3	44.4
C-18	8.3	9.5		12.5	6.9	11.4	
C-19		4.8		10.0		14.2	
C-20		9.5					
C-21							
C-22		4.8				7.1	
C-23							
C-24	8.3	4.8			6.9		
C-25		9.5	50.0	10.0	6.9		
C-26	8.3	4.8		10.0	6.9	7.1	
C-27		4.8		10.0			
C-28	8.3	14.3	50.0	10.0		7.1	11.1
C-29	16.7						
C-30	16.7					28.4	
C-31	8.3						
C-32	8.3						
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 5. (continued)

Sample	XLIII	XLIV	XLV	XLVI	XLVII	XLVIII	XLIX
C-12				0			
C-13							
C-14						2.6	
C-15	15.3	8.3				5.1	
C-16					9.1	5.1	
C-17	24.5	8.3			18.2	10.3	14.2
C-18	7.4	4.2			36.4	6.2	14.2
C-19		4.2			36.4	5.1	14.2
C-20			8.7			2.6	
C-21		4.2	4.3			5.1	7.3
C-22		8.3	8.7			6.2	
C-23		8.3	8.7			6.2	
C-24	7.4	8.3	8.7			5.1	
C-25	15.3	16.7	8.7			5.1	14.2
C-26	7.4	8.3	8.7			5.1	14.2
C-27	7.4	8.3	8.7			5.1	
C-28	15.3	8.3	8.7			6.2	14.2
C-29		4.2	8.7			6.2	7.3
C-30			8.7			2.6	
C-31			8.7			2.6	
C-32						2.6	
C-33						2.6	
C-34						2.6	
C-35							
C-36							
C-37							

TABLE 5. (continued)

Sample	L	LI	LII	LIII	LIV	LV	LVI
C-12		0	0	0	0		0
C-13							
C-14							
C-15							
C-16							
C-17	5.9						
C-18	2.9						
C-19	11.8						
C-20							
C-21	11.8						
C-22	11.8					25.0	
C-23	11.8						
C-24						25.0	
C-25						25.0	
C-26	5.9						
C-27	5.9						
C-28						25.0	
C-29	5.9						
C-30	5.9						
C-31	5.9						
C-32	2.9						
C-33							
C-34	5.9						
C-35	5.9						
C-36							
C-37							

TABLE 5. (continued)

Sample	LVII	LVIII	LIX	LX	LXI	LXII	LXIII
C-12			0				
C-13							
C-14							0.2
C-15				4.1	4.8		2.2
C-16	4.6	0.9		6.1	4.8	3.7	3.7
C-17	13.8	3.7		16.3	9.5	7.4	6.5
C-18	4.6	8.4		8.2	4.8	7.4	6.5
C-19	18.3	14.9		8.2	4.8	7.4	6.5
C-20	18.3	8.4		8.2	4.8	7.4	4.3
C-21	4.6	17.7		4.1	4.8	11.1	2.2
C-22		13.0		4.1		3.7	15.2
C-23		16.7		2.0	4.8		6.5
C-24		3.7		2.0	4.8		6.5
C-25	9.2			6.1	9.5	7.4	8.7
C-26	4.6	1.9		4.1	4.8	7.4	6.5
C-27	9.2	1.9		6.1	4.8	11.1	5.4
C-28	9.2			8.2	9.5	14.8	8.7
C-29	3.7	0.9		2.0	4.8	7.4	6.5
C-30		0.5		4.1	4.8	3.7	
C-31				2.0	4.8		2.2
C-32		0.9		4.1	4.8		
C-33		0.9			4.8		0.2
C-34		1.9					0.7
C-35		1.9					0.7
C-36		1.9					
C-37							

TABLE 5. (continued)

Sample	LXIV	LXV	LXVI	LXVII	LXVIII	LXIX	LXX
C-12							
C-13							
C-14							
C-15	13.3		3.8	2.4	9.1		
C-16	13.3	2.9	15.4	5.9	9.1		
C-17	26.7	8.8	30.8	11.8	18.2	44.4	10.0
C-18	13.3	8.8	3.8	17.6	9.1	55.6	
C-19		5.9	3.8	17.6			
C-20	13.3	5.9		11.8			
C-21		5.9		5.9			
C-22	6.7	2.9	3.8	2.4			
C-23			3.8	2.4			
C-24		5.9					
C-25	6.7	11.8	15.4	14.1			
C-26		8.8	3.8		9.1		
C-27		8.8	7.7		18.2		
C-28	6.7	17.6	7.7	5.9	18.2		
C-29		5.9		2.4	9.1		
C-30							
C-31							
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 5. (continued)

Sample	LXXI	LXXII	LXXIII	LXXIV	LXXV	LXXVI
C-12	0					
C-13						
C-14						
C-15						
C-16						20.0
C-17		10.0	10.0	44.4	15.4	40.0
C-18				55.6	7.7	20.0
C-19					15.4	
C-20					15.4	20.0
C-21					15.4	
C-22					15.4	
C-23					7.7	
C-24					7.7	
C-25						
C-26						
C-27						
C-28						
C-29						
C-30						
C-31						
C-32						
C-33						
C-34						
C-35						
C-36						
C-37						

TABLE 6.

ADDITIONAL ANALYTICAL DATA FOR WATER SAMPLES

Sample	Total n-Alkanes (ppb)	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	11.9	0.80	0.22	0.70
II	3.4	0.80	0.27	0.58
III	5.3	0.82	0.33	0.91
IV	4.5	0.70	0.50	1.03
V	1.9	--	--	1.47
VI	1.1	--	--	0.94
VII	0.7	--	--	1.00
VIII	2.0	0.65	0.50	0.95
IX	14.3	1.00	0.50	0.95
X	24.8	--	--	1.43
XI	1.1	0.90	0.50	1.20
XII	10.5	--	--	1.33
XIII	35.3	0.69	0.52	1.26
XIV	23.1	0.50	0.75	0.99
XV	21.2	0.71	0.48	1.09
XVI	7.7	1.00	0.50	1.10
XVII	9.5	0.71	0.50	0.99
XVIII	8.6	0.70	0.42	1.10
XIX	14.1	0.72	0.46	1.01
XX	14.1	0.85	0.40	1.09
XXI	4.6	0.67	0.50	1.07
XXII	17.7	0.50	0.50	1.05
XXIII	7.1	0.67	0.47	1.03
XXIV	1.2	1.00	0.50	0.92
XXV	9.2	0.71	0.46	1.22
XXVI	1.3	1.00	0.50	1.00
XXVII	5.7	1.00	0.44	1.05
XXVIII	3.0	1.20	1.00	1.00
XXIX	6.4	0.63	0.44	0.90
XXX	3.3	1.00	1.00	1.06
XXXI	17.7	0.67	0.50	1.03
XXXII	3.7	0.67	0.50	1.18
XXXIII	29.7	0.79	0.51	1.06
XXXIV	1.7	1.00	--	1.07
XXXV	0.15	--	--	1.00
XXXVI	0.60	--	--	0.72
XXXVII	0.53	1.00	--	0.75
XXXVIII	0.05	--	--	1.00
XXXIX	0.20	1.50	1.00	1.22
XL	0.17	1.00		0.72

TABLE 6. (continued)

Sample	Total n-Alkanes (ppb)	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
XLI	0.35	1.00	1.00	0.55
XLII	0.23	--	--	0.80
XLIII	0.16	1.00	0.83	0.89
XLIV	0.60	1.00	1.00	1.19
XLV	4.6	--	--	0.92
XLVI	0	--	--	--
XLVII	0.6	1.00	2.00	1.20
XLVIII	1.0	1.00	0.83	1.13
XLVIX	2.5	0	0	1.35
L	0.9	1.00	2.00	1.83
LI	0	--	--	--
LII	0	--	--	--
LIII	0--	--	--	
LIV	0	--	--	--
LV	0.4	--	--	0.33
LVI	0	--	--	--
LVII	0.5	1.33	2.00	1.42
LVIII	10.8	1.00	0.67	1.41
LIX	0	--	--	--
LX	2.5	0.75	0.50	1.04
LXI	2.1	0.75	1.00	1.31
LXII	2.7	1.00	0.50	.08
LXIII	4.6	0.77	0.43	.91
LXIV	0.8	1.00	0	0.88
LXV	34	0	0	0.89
LXVI	2.4	0.75	1.00	1.89
LXVII	0.9	1.50	0.67	1.29
LXVIII	3.3	1.00	1.50	1.20
LXIX	1.8	--	--	0.80
LXX	0.5	--	--	--
LXXI	0	--	--	--
LXXII	1.2	--	--	--
LXXIII	0.7	--	--	--
LXXIV	0.9	--	0.40	0.80
LXXV	0.3	0	0	1.60
LXXVI	0.1	0	2.00	0.66

TABLE 7.

TABULATION OF BARNACLE SAMPLES

Sample	Date	Location*	Depth	Material
I	9-25-76	Pfm A	surface	flesh
II	9-25-76	Pfm A	surface	shell
III	9-25-76	Pfm A	10 m	flesh
IV	9-25-76	Pfm A	10 m	shell
V	9-25-76	Pfm B	surface	flesh
VI	9-25-76	Pfm B	surface	shell
VII	9-25-76	Pfm B	10 m	flesh
VIII	9-25-76	Pfm B	10 m	shell
IX	9-25-76	Jkt I	surface	flesh
X	9-25-76	Jkt I	surface	shell
XI	9-25-76	Jkt I	surface	flesh
XII	9-25-76	Jkt I	10 M	shell
XIII	9-25-76	Jkt A	surface	flesh
XIV	9-25-76	Jkt A	surface	shell
XV	9-25-76	Jkt A	10 m	flesh
XVI	9-25-76	Jkt A	10 m	shell
XVII	9-25-76	Jkt K	surface	flesh
XVIII	9-25-76	Jkt K	surface	shell
XIX	9-25-76	Jkt K	10 m	flesh
XX	9-25-76	Jkt K	10 m	shell
XXI	9-25-76	Jkt H	surface	flesh
XXII	9-25-76	Jkt H	surface	shell
XXIII	9-25-76	Jkt H	10 m	flesh
XXIV	9-25-76	Jkt H	10 m	shell
XXV	9-25-76	Jkt C	surface	flesh
XXVI	9-25-76	Jkt C	surface	shell
XXVII	9-25-76	Jkt C	10 m	flesh
XXVIII	9-25-76	Jkt C	10 m	shell
XXIX	9-25-76	Jkt F	surface	flesh
XXX	9-25-76	Jkt F	surface	shell
XXXI	9-25-76	Jkt F	10 m	flesh
XXXII	9-25-76	Jkt F	10 m	shell
XXXIII	9-25-76	Jkt G	surface	flesh
XXXIV	9-25-76	Jkt G	surface	shell
XXV	9-25-76	Jkt G	10 m	flesh
XXVI	9-25-76	Jkt G	10 m	shell
XXXVII	1-21-77	Pfm A	surface	flesh
XXXVIII	1-21-77	Pfm A	surface	shell
XXXIX	1-21-77	Pfm A	13 m	flesh
XL	1-21-77	Pfm A	13 m	shell

TABLE 7. (continued)

Sample	Date	Location*	Depth	Material
XLI	1-22-77	Jkt 0	surface	flesh
XLII	1-22-77	Jkt 0	surface	shell
XLIII	1-22-77	Jkt 0	13 m	flesh
XLIV	1-22-77	Jkt 0	13 m	shell
XLV	3-2-77	Jkt I	12 m	flesh
XLVI	3-2-77	Jkt I	12 m	shell
XLVII	3-2-77	Jkt K	11 m	flesh
XLVIII	3-2-77	Jkt K	11 m	shell
XLIX	3-2-77	Jkt N	7.5 m	flesh
L	3-2-77	Jkt N	7.5 m	shell
LI	3-2-77	Jkt N	15 m	flesh
LII	3-2-77	Jkt N	15 m	shell
LIII	3-2-77	Jkt M	15 m	flesh
LIV	3-2-77	Jkt M	15 m	shell
LV	3-2-77	Jkt M	7.5 m	flesh
LVI	3-2-77	Jkt M	7.5 m	shell

*See Figure 8.

TABLE 8.

DISTRIBUTION OF n-ALKANES IN BARNACLE SAMPLES

Sample	I	II	III	IV	V	VI	VII
C-12	4.5				0.5		
C-13	6.3				2.3		
C-14	7.9		10.5		3.2		1.8
C-15	28.9	8.9	32.9	7.4	54.8	7.4	32.1
C-16	6.8	8.9	3.0	3.1	0.7	2.8	3.9
C-17		15.4	18.0	16.4	1.8	14.8	20.1
C-18	3.7	8.1	1.5	2.5	0.5	3.7	1.8
C-19	3.4	8.1	0.3	3.9	0.5	4.6	0.8
C-20	2.1	4.9	1.5	1.2	0.2	1.9	0.8
C-21	15.0	7.3	19.5	7.8	17.5	7.4	26.1
C-22	1.8	4.0	0.6	2.5	0.5	2.8	0.8
C-23	2.6	4.9	1.5	4.3	5.3	3.7	1.8
C-24	2.6	5.7	1.5	7.0	1.8	6.5	1.8
C-25	3.2	6.5	1.5	9.0	2.8	11.1	1.8
C-26	1.8	4.0	0.6	8.8	1.4	9.3	0.8
C-27	1.8	3.2	0.3	7.4	1.8	7.4	0.8
C-28	1.8	3.2	0.6	5.7	1.1	5.6	1.0
C-29	0.8	2.4	0.3	4.3	0.5	3.7	0.3
C-30	0.3	1.6		2.9	0.2	1.9	
C-31	1.8	1.6	1.5	2.0	1.1	1.9	0.8
C-32	0.8	0.8		1.2	0.5	0.9	
C-33	1.8	0.4	4.5	0.6	1.2		1.6
C-34				0.4		0.9	
C-35				1.6		1.9	
C-36							
C-37							

TABLE 8. (continued)

Sample	VIII	IX	X	XI	XII	XIII	XIV
C-12							
C-13		1.0				1.5	0.5
C-14		1.3		1.3		4.6	1.0
C-15	3.8	15.7	7.5	33.4	3.4	54.2	9.5
C-16	1.5	6.3	2.5	4.0	1.7	6.2	4.0
C-17	9.1	22.0	18.8	24.0	15.4		22.5
C-18	2.3	3.1	1.8	1.3	2.3	3.1	2.0
C-19	3.8	2.1	2.0	1.3	6.8	3.1	6.5
C-20	0.8	2.1	1.0	1.3	1.1	0.9	1.5
C-21	21.3	24.1	8.3	20.0	18.8	21.7	10.0
C-22	1.9	2.1	2.0	0.9	1.7	1.5	2.0
C-23	4.6	3.1	4.0	1.6	4.0	1.5	3.5
C-24	6.8	2.5	6.8	1.3	6.3	1.5	5.5
C-25	9.1	3.1	8.8	2.4	8.5		6.5
C-26	8.4	1.9	8.8	1.3	7.4		6.0
C-27	7.6	2.1	7.5	1.1	6.8		5.5
C-28	6.1	1.0	6.3	1.3	5.7		4.0
C-29	4.6	0.4	5.0	0.3	3.4		3.0
C-30	3.0	0.2	3.3	0.3	2.3		2.0
C-31	2.3		2.5	1.1	1.7		1.5
C-32	0.8	1.0	1.3	0.3	1.1		0.5
C-33	0.8	1.0	0.5	1.3	0.6		0.5
C-34	0.4	0.4	0.5		0.3		0.5
C-35	1.1	2.1	1.3	0.6		0.5	
C-36		1.0					
C-37							

TABLE 8. (continued)

Sample	XV	XVI	XVII	XVIII	XIX	XX	XXI
C-12							
C-13					4.1		
C-14	5.1				1.9		2.1
C-15	30.8	10.5	38.9	3.9	42.0	5.6	53.6
C-16	5.1	3.1	8.0	1.4	4.1	1.2	3.9
C-17	25.7	16.6		7.8		16.2	3.0
C-18	0.5	2.2	4.4	1.7	1.4	1.4	1.8
C-19		5.2	3.5	6.7	0.3	4.3	0.9
C-20		1.7		0.8	0.5	0.5	0.9
C-21	30.8	2.6	30.1	0.3	23.0	2.0	16.1
C-22	0.3	2.2	1.8	2.5	1.4	2.0	1.2
C-23	0.3	4.4	3.5	6.1	2.7	5.5	3.0
C-24	0.3	7.0	1.8	9.7	1.4	8.9	2.1
C-25	0.3	9.6	3.5	12.5	1.9	11.2	2.1
C-26		8.7	0.9	12.5	1.1	10.9	0.9
C-27		7.4	0.9	10.6	1.4	9.4	1.2
C-28		5.7	2.7	7.8	0.5	6.8	0.9
C-29		4.4		6.1	0.3	5.1	0.3
C-30		2.2		3.6	0.3	3.4	0.3
C-31		2.2		2.5	0.3	2.6	0.9
C-32		0.9		1.4		1.0	0.3
C-33	0.8	0.4		0.8	1.9	0.5	3.9
C-34		0.9		0.3	1.6	0.5	0.3
C-35		2.2		1.1	8.1	1.0	
C-36							
C-37							

TABLE 8. (continued)

Sample	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVIII
C-12							
C-13							1.0
C-14							0.5
C-15	5.9	16.9	1.4	40.7	7.0		7.0
C-16	2.6	6.0	0.8	6.8	4.4		3.3
C-17	11.3	21.7	3.9		39.3	62.8	16.0
C-18	2.6	2.4	0.8	16.9	9.2	4.7	3.5
C-19	7.7	1.2	2.2		4.4	2.3	4.0
C-20	2.0		0.5	1.7	1.8		2.5
C-21	1.5	44.6	7.3	6.8	2.2	18.6	15.0
C-22	3.1	1.2	3.7	1.7	1.8	2.3	2.5
C-23	5.6	1.2	7.6	3.4	2.9	2.3	3.0
C-24	8.7	1.2	11.0	3.4	4.0	2.3	5.0
C-25	11.8	1.2	12.7	5.1	4.4	2.3	7.5
C-26	10.2	1.2	12.2	3.4	4.4	1.2	13.0
C-27	9.2	1.2	10.7	3.4	4.0	1.2	1.0
C-28	6.6		8.3	1.7	3.7		3.5
C-29	4.6		6.6		2.2		3.0
C-30	2.6		3.7	1.7	1.5		2.0
C-31	1.5		2.7		1.1		1.5
C-32	0.5		1.7		0.7		1.0
C-33	0.5		1.0	3.4			0.5
C-34	0.5		0.5		0.4		0.5
C-35	1.0		0.7		0.4		2.5
C-36							
C-37							

TABLE 8. (continued)

Sample	XXIX	XXX	XXXI	XXXII	XXXIII	XXXIV	XXXV
C-12					1.7		
C-13					2.4	0.6	
C-14			1.4		5.9	0.6	
C-15	43.6	3.1	31.2	7.1	35.0	7.8	71.0
C-16	7.3	1.9	5.7	1.8	3.5	3.4	7.3
C-17	23.3	10.6	28.3	33.9	1.7	11.8	2.0
C-18	2.9	2.5	1.4	3.6	1.0	2.8	1.6
C-19	0.9	3.7	1.4	12.5	1.0	2.8	
C-20	0.9	0.9	0.6	1.8	0.3	1.1	0.8
C-21	11.6	0.9	21.2	7.1	18.2	12.9	2.0
C-22	0.9	2.5	1.4	1.8	1.7	1.7	0.8
C-23	0.9	5.0	2.8	1.8	3.5	4.5	
C-24	0.9	9.3	1.4	3.6	3.1	6.7	0.8
C-25	0.9	11.2	1.4	5.4	4.2	9.5	0.4
C-26		11.2		5.4	3.1	8.4	
C-27		9.3		3.6	3.1	7.3	
C-28		7.2		3.6	1.7	5.6	2.9
C-29		5.6		3.6	1.0	4.5	
C-30	0.9	3.7		1.8	0.3	2.8	
C-31	0.9	2.5	0.6	1.8	1.7	2.2	7.3
C-32	0.9	5.0	0.6		0.3	1.1	
C-33	3.5	1.2	0.6		4.9	0.6	2.0
C-34		0.6				0.3	0.8
C-35		1.7				1.1	
C-36							
C-37							

TABLE 8. (continued)

Sample	XXXVI	XXXVII	XXXVIII	XXXIX	XL	XLI	XLII
C-12			3.5				
C-13			3.5		2.0	7.7	
C-14			3.5		1.0	3.8	1.6
C-15	4.8	2.4	15.7	22.7	35.0	38.5	26.0
C-16	2.0	2.4	4.3	2.3	3.0	3.8	4.9
C-17	8.8		17.4		7.0		27.6
C-18	2.0	2.4	3.5	2.3	3.0	1.9	4.9
C-19	4.4	4.8	3.5	18.2	2.0	11.5	6.5
C-20	2.0		1.7		1.0		
C-21	8.8	81.9	8.7	22.7	18.0	7.7	3.9
C-22	2.7		1.7	2.3	1.0	1.9	0.8
C-23	4.4		3.5	2.2	2.0	3.8	1.6
C-24	6.1	4.5	5.2	4.5	3.0	3.8	3.3
C-25	8.5	1.2	7.0	4.5	4.0	3.8	4.9
C-26	8.2	1.2	5.2	4.5	4.0	3.8	3.3
C-27	7.5	1.2	5.2	9.1	4.0	3.8	3.3
C-28	6.1	1.2	3.5		3.0	3.8	1.6
C-29	4.4		2.6	4.5	2.0		1.6
C-30	2.7				2.0		1.6
C-31	2.0		0.9		2.0		1.6
C-32	0.7				1.0		
C-33	0.3						
C-34	2.4						
C-35	6.8						
C-36	4.1						
C-37							

TABLE 8. (continued)

Sample	XLIII	XLIV	XLV	XLVI	XLVII	XLVIII	XLIX
C-12							
C-13							
C-14		1.6					
C-15	14.0	24.4		4.2	6.5	9.9	0.6
C-16	4.7	3.3		1.9	5.6	1.2	26.8
C-17		11.4	81.9	11.1	65.7	8.6	61.2
C-18	4.7	4.9	2.9	1.9	2.8	2.5	1.5
C-19	14.0	3.3	8.8	2.8	5.6	6.2	3.8
C-20		0.8	0.6	1.9	0.8	2.5	0.3
C-21	41.9	26.0	5.8	1.9	7.6	2.5	5.1
C-22		0.8		1.9	0.5	1.2	0.3
C-23		1.6		4.6	0.8	6.2	0.1
C-24	2.3	3.3		3	0.8	14.8	0.1
C-25	4.7	4.9		20.4	0.8	24.7	0.1
C-26	4.7	3.3		7.4	0.8		
C-27	4.7	3.3		7.4	0.8		
C-28	4.7	3.3		9.3	0.5	13.6	
C-29		1.6		5.6		6.2	
C-30		0.8		1.9			
C-31		1.6					
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 8. (continued)

Sample	L	LI	LII	LIII	LIV	LV	LVI
C-12							
C-13							
C-14							0.4
C-15	7.8	7.0	11.6	34.6	5.7		4.4
C-16	5.9	3.5		1.8	2.3		3.6
C-17	15.7	1.7	3.5	1.8	13.6	3.0	5.1
C-18	3.9	1.7	3.5	1.8	13.6	3.0	5.1
C-19	2.6	24.4	7.0	3.6	3.4	8.9	5.8
C-20	2.6	0.4	2.3	0.4	2.3	0.3	2.2
C-21	6.5	16.5	7.0	3.6	2.3	20.7	5.8
C-22	3.9	0.2	2.3	0.2	3.4	0.3	4.4
C-23	5.2	0.2	4.7	0.2	5.7	0.3	5.1
C-24	9.2	0.2	7.0	0.2	8.0	0.3	8.0
C-25	11.8	0.2	11.6	0.2	9.1	0.3	9.5
C-26	9.2	0.2	9.3	0.2	8.0	0.3	8.7
C-27	7.8	0.2	10.5	0.2	8.0	0.3	6.5
C-28	6.5	0.2		0.2	5.7	0.3	4.4
C-29	1.3				3.4		2.2
C-30					1.1		0.7
C-31							
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 9.

ADDITIONAL ANALYTICAL DATA FOR BARNACLE SAMPLES

Sample	Total n-Alkanes (ppb)	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	380	--	2.14	1.93
II	247	0.74	0.50	1.43
III	334	6.50	4.00	4.05
IV	244	0.33	0.17	1.83
V	571	70.0	7.67	8.43
VI	108	1.00	0.25	1.75
VII	383	4.29	3.57	6.87
VIII	263	0.67	0.33	2.13
IX	477	3.05	2.33	3.37
X	400	0.43	0.14	1.92
XI	375	3.33	5.00	6.52
XII	176	0.41	0.75	2.34
XIII	323	--	6.50	4.62
XIV	198	0.51	0.75	2.45
XV	389	2.40	10.0	7.85
XVI	229	0.13	0.40	1.89
XVII	565	--	3.60	4.14
XVIII	180	0.79	0.50	1.40
XIX	389	--	8.00	4.40
XX	587	0.32	0.63	1.73
XXI	330	80.0	5.50	5.80
XXII	196	0.50	0.40	1.54
XXIII	415	1.94	2.50	7.30
XXIV	591	0.43	0.20	1.31
XXV	295	--	0	1.68
XXVI	272	0.31	0.36	2.13
XXVII	215	0.67	2.00	8.52
XXVIII	199	0.44	0.29	1.68
XXIX	344	4.38	2.50	5.80
XXX	161	0.44	0.75	1.23
XXXI	353	4.25	7.60	7.00
XXXII	112	0.47	0.50	3.27
XXXIII	286	100	10.0	3.42
XXXIV	179	0.81	0.20	1.90
XXXV	2450	2.40	--	5.67
XXXVI	294	0.54	0.33	1.56
XXXVII	415	--	--	10.9
XXXVIII	115	4.20	1.00	2.12
XXXIX	220	--	--	5.29
XL	100	1.43	0.33	3.55

TABLE 9. (continued)

Sample	Total n-alkanes (ppb)	Pristane/ n-C-1	Phytane/ n-C-18	Odd/Even Preference
XLI	260	--	2.00	3.39
XLII	62	3.53	0.50	3.55
XLIII	215	--	--	3.74
XLIV	62	1.43	0.50	3.52
XLV	342	1.11	1.00	27.6
XLVI	216	0.96	0.50	1.38
XLVII	354	0.73	0.17	7.47
XLVIII	162	0.71	0.50	1.79
XLIX	784	0.71	0.42	2.45
L	153	0.83	0.67	1.43
LI	1149	0.38	0.50	14.63
LII	86	0.60	0.33	3.10
LIII	549	0.86	0.50	19.8
LIV	88	0.75	0.8	1.25
LV	338	0.55	0.25	21.22
LVI	138	0.66	0.43	1.67

TABLE 10.

TABULATION OF SHRIMP AND SQUID SAMPLES

Sample	Date	Location*	Species	Collection Method
I	8-9-76	S-2	brown shrimp (Penaeus aztecus)	trawl
II	8-9-76	P-7	white squid (Lolliguncula brevis)	trawl
III	8-10-76	P-7	brown shrimp (Penaeus aztecus)	trawl
IV	2-16-77	P-6	brown shrimp (Penaeus aztecus)	trawl
V	2-16-77	P-6	pink shrimp (Penaeus duorarum)	trawl
VI	2-16-77	P-6	sugar shrimp (Trachypenaeus similis)	trawl
VII	2-16-77	P-6	mantis shrimp (Squilla empusa)	trawl
VIII	2-16-77	P-6	white squid (Lolliguncula brevis)	trawl
IX	11-15-76	V-4	white squid (Lolliguncula brevis)	trawl
X	8-9-76	V-4	white squid (Lolliguncula brevis)	trawl

*See Figure 9.

TABLE 11.

DISTRIBUTION OF n-ALKANES IN SHRIMP AND SQUID SAMPLES

Sample	I	II	III	IV	V	VI	VII
C-12							
C-13	8.3						
C-14	4.2						
C-15	8.3	16.0		2.2		3.2	
C-16	12.5	0.4		4.5		6.5	
C-17	20.8	76.8	1.3	6.3	20.0	12.9	5.9
C-18	6.3	1.5		2.2	10.0	6.5	5.9
C-19	4.2	0.8	6.7	6.3	10.0	6.5	11.8
C-20	6.3	0.8	0.7	6.3	10.0	6.5	
C-21	4.2	0.8	1.3	9.0	20.0	16.1	47.1
C-22	4.2	0.4	5.4	11.3	10.0	3.2	11.8
C-23	4.2	0.8	12.2	13.5	10.0	6.5	5.9
C-24	4.2	0.8	17.5	13.5	10.0	6.5	5.9
C-25	4.2	1.1	17.5	9.0		6.5	5.9
C-26	4.2		14.9	2.2		6.5	
C-27			10.8	2.2		6.5	
C-28	4.2		6.7			6.5	
C-29			4.1				
C-30			0.7				
C-31							
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 11. (continued)

Sample	VIII	IX	X
C-12			
C-13			
C-14		1.5	
C-15	5.1	52.9	27.6
C-16		6.4	0.5
C-17	92.3	20.1	65.9
C-18	2.6	2.7	1.4
C-19		2.7	0.9
C-20		0.9	1.4
C-21		1.8	0.5
C-22		1.8	0.5
C-23		1.8	1.4
C-24		1.8	
C-25		2.7	
C-26		1.8	
C-27			
C-28		0.9	
C-29			
C-30			
C-31			
C-32			
C-33			
C-34			
C-35			
C-36			
C-37			

TABLE 12.

ADDITIONAL ANALYTICAL DATA FOR SHRIMP AND SQUID SAMPLES

Sample	Total n-alkanes (ppm)	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	0.24	1.00	1.33	1.17
II	1.32	--	--	24.6
III	2.45	0.52	--	1.18
IV	0.11	1.71	6.80	1.14
V	0.05	1.50	0	1.50
VI	0.08	2.50	2.00	1.37
VII	0.04	2.00	1.00	3.24
VIII	0.98	0	1.00	37.5
IX	5.48	5.45	0.67	4.67
X	2.17	--	--	25.3

TABLE 13.

TABULATION OF PLANKTON SAMPLES

Sample	Date	Location*	Collection method
I	5-24-76	N-6	bongo
II	5-24-76	P-7	bongo
III	5-24-76	S-10	bongo
IV	5-25-76	P-6	bongo
V	8-16-76	K-3	bongo
VI	8-16-76	N-6	bongo
VII	8-17-76	P-6	bongo
VIII	8-17-76	S-10	bongo
IX	12-3-76	H-2	neuston
X	12-3-76	H-4	neuston
XI	12-3-76	H-5	neuston
XII	12-3-76	H-6	neuston
XIII	12-3-76	B	neuston
XIV	12-3-76	C	neuston
XV	12-3-76	F	neuston
XVI	12-3-76	G	neuston
XVII	2-13-77	X	500m net (66ft)
XVIII	2-16-77	P	500m net (70ft)

*See Figure 9.

TABLE 14.

DISTRIBUTION OF n-ALKANES IN PLANKTON SAMPLES

Sample	I	II	III	IV	V	VI	VII
C-12	2.9		2.6				
C-13	1.8		2.0				
C-14	1.5	3.6	2.0				
C-15	7.3	16.9	29.8	3.0	14.3	22.7	14.0
C-16	5.1	8.4	4.6	2.0	8.4	15.5	15.2
C-17	6.5	10.8	7.3	12.1	18.5	18.2	23.3
C-18	3.6	6.0	3.3	16.2	8.4	5.5	11.1
C-19	3.6	2.4	2.6	8.1	5.9	3.6	5.8
C-20			0.7	4.0	11.8	1.8	3.5
C-21	0.7	1.2	2.0	4.0	8.4	1.8	2.9
C-22	18.2	24.1	3.3	4.0	6.7	3.6	4.7
C-23	1.5	2.4	2.0	8.1	4.2	4.5	4.1
C-24	2.2	3.6	2.6	6.1	5.9	4.5	4.1
C-25				6.1		4.5	3.5
C-26		1.2	1.3	6.1		1.8	2.0
C-27	1.5	6.0	2.0	2.0		1.7	1.4
C-28	40.7	10.8	29.1	6.1		6.4	1.4
C-29	1.5		1.3	8.1	3.4	1.8	0.6
C-30	1.5	2.4	0.7	4.0	4.2	0.9	0.6
C-31			0.7				0.8
C-32							0.9
C-33							0.3
C-34							0.6
C-35							0.3
C-36							
C-37							

TABLE 14. (continued)

Sample	VIII	IX	X	XI	XII	XIII	XIV
C-12							
C-13							
C-14		2.3	0.2	1.4	1.3	0.9	0.3
C-15	18.5	9.3	1.8	14.2	13.2	5.2	0.4
C-16	9.2	7.0	0.9	5.3	3.5	4.3	0.3
C-17	13.8	9.3	2.2	24.9	30.7	8.7	1.2
C-18	7.7	4.7	0.4	7.1	2.2	5.2	0.3
C-19	4.6	4.7	0.9	5.3	4.4	4.3	0.4
C-20	3.1	2.3		1.4		2.2	0.6
C-21	3.1	1.2	0.2	1.4	0.9	2.2	1.2
C-22	4.6	4.7	0.2	3.6	3.5	4.3	4.5
C-23	4.6	4.7	0.2	3.6	4.4	5.2	8.9
C-24	4.6	7.0	1.6	5.3	6.6	8.7	13.1
C-25	12.3	11.6	1.8	5.3	8.8	8.7	15.5
C-26	0.8	7.0	1.1	5.3	8.8	9.5	14.0
C-27	4.6	7.0	10.3	3.6	6.6	4.3	15.2
C-28	4.6	9.3	0.9	3.6	4.4	8.7	8.9
C-29	3.1	2.3	9.9	1.4	0.9	4.3	4.5
C-30	0.8	4.7	1.3	1.4		3.5	2.4
C-31		1.2	45.8	1.4		4.3	1.8
C-32			1.3	1.4		0.9	2.7
C-33			18.0	1.4		2.2	1.2
C-34			0.4	1.4		0.9	0.9
C-35			0.2			0.9	0.9
C-36			0.2			0.9	0.6
C-37							0.3

TABLE 14. (continued)

Sample	XV	XVI	XVII	XVIII
C-12				
C-13				
C-14	0.4			
C-15	1.6	6.9		
C-16	2.4	2.3		
C-17	13.5	39.1	43.2	12.1
C-18	4.8	4.6	5.4	6.1
C-19	6.4	4.6	35.1	6.1
C-20	4.0	4.6	5.4	6.1
C-21	4.3	1.1	5.4	6.1
C-22	4.8	1.1	5.4	6.1
C-23	5.6	1.1		6.1
C-24	7.2	2.3		9.1
C-25	8.0	2.3		12.1
C-26	7.2	3.4		12.1
C-27	6.4	2.3		12.1
C-28	5.5	3.4		6.1
C-29	4.0	1.1		
C-30	3.2	1.1		
C-31	2.7	1.1		
C-32	2.4	1.1		
C-33	2.4	1.1		
C-34	1.6	2.3		
C-35	1.0	3.4		
C-36	0.8	4.6		
C-37		4.6		

TABLE 15.

ADDITIONAL ANALYTICAL DATA FOR PLANKTON SAMPLES

Sample	Total n-Alkanes (ppb)	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	1375	0.60	0.50	0.41
II	830	0.90	0.33	0.70
III	1510	0.80	0.60	2.47
IV	240	0.90	0.50	1.06
V	1190	0.90	0.50	1.20
VI	1100	1.00	0.50	1.50
VII	858	1.05	0.35	1.33
VIII	650	1.00	0.50	1.83
IX	215	8.00	0.50	1.04
X	2225	3.60	0.50	11.05
XI	141	2.91	0.50	1.69
XII	228	0.18	0.40	2.30
XIII	231	11.25	0.83	1.00
XIV	3360	5.00	2.00	1.06
XV	628	0.76	0.40	1.25
XVI	435	0.53	0.75	2.25
XVII	370	0.56	0.50	5.17
XVIII	825	0	0.50	1.19

TABLE 16.

TABULATION OF FISH SAMPLES

Sample	Date	Location*	Species	Tissue
I	8-9-76	S-2	sand seatrout	muscle
II			*Cyonoscion arenarius*	liver
III	8-9-76	S-3	blackfin searobin	muscle
IV			*Prionotus rubio*	liver
V	8-9-76	S-3	red snapper	muscle
VI			*Lutjanus campechanus*	liver
VII	8-9-76	V-4	southern kingfish	muscle
VIII			*Menticirrhus americanus*	liver
IX	8-9-76	V-4	inshore lizardfish	muscle
X			*Synodus foetens*	liver
XI	8-9-76	P-7	inshore lizardfish	muscle
XII			*Synodus foetens*	liver
XIII	8-9-76	P-7	red snapper	muscle
XIV			*Lutjanus campechanus*	liver
XV	8-9-76	P-7	sand seatrout	muscle
XVI			*Cyonoscion arenarius*	liver
XVII	8-10-76	P-5	blackfin searobin	muscle
XVIII			*Prionotus rubio*	liver
XIX	8-10-76	P-7	longspine porgy	muscle
			Stenotomus caprinus	
XX	8-11-76	J-9	atlantic midshipman	muscle
XXI			*Porichthys porosissimus*	liver
XXII	1-21-77	Pfm B	bluefish	muscle
XXIII			*Pomatomus saltatrix*	liver
XXIV	1-21-77	Pfm B	bluefish	muscle
XXV			*Pomatomus saltatrix*	liver
XXVI	2-15-77	X-3	atlantic croaker	muscle
			Micropogon undulatus	
XXVII	2-15-77	X-3	sea catfish	muscle
XXVIII			*Arius felis*	liver
XXIX	2-15-77	X-3	sand seatrout	muscle
XXX			*Cyonoscion arenarius*	liver

TABLE 16. (continued)

XXXI	2-16-77	P-6	largescale lizardfish	muscle
XXXII			*Saurida brasiliensis*	liver
XXXIII	2-16-77	P-6	sea catfish	muscle
XXXIV			*Arius felis*	liver
XXXV	2-16-77	P-6	roughback batfish	muscle
XXXVI			*Ogcocephalus parus*	liver
XXXVII	2-16-77	P-6	southern hake	muscle
XXXVIII			*Urophycis floridanus*	liver
XXXIX	2-16-77	P-6	rock seabass	muscle
XL			*Centropristis philadelphica*	liver
XLI	2-16-77	P-6	dwarf sandperch	muscle
XLII			*Diplectrum bivittatum*	liver
XLIII	2-16-77	P-6	pigfish	muscle
XLIV			*Orthopristis chrysoptera*	liver
XLV	2-16-77	P-6	atlantic croaker	muscle
XLVI			*Micropogon undulatus*	liver
XLVII	2-16-77	P-6	gulf butterfish	muscle
			Peprilus burti	
XLVIII	2-16-77	P-6	smoothead scorpionfish	muscle
			Scorpaena calcarata	
XLIX	2-16-77	P-6	bandtail searobin	muscle
			Prionotus ophryas	
L	2-16-77	P-6	bay whiff	muscle
			Citharichthys spilopterus	
LI	2-16-77	P-6	dusky flounder	muscle
LII			*Syacium papillosum*	liver
LIII	2-16-77	P-6	blackcheek tonguefish	muscle
			Symphurus plagiusa	
LIV	2-16-77	Pfm A	pigfish	muscle
LV			*Orthopristis chrysoptera*	liver
LVI	2-16-77	Pfm A	atlantic spadefish	muscle
LVII			*Chaetodipterus faber*	liver
LVIII	2-16-77	Pfm B	leopard toadfish	muscle
LIX			*Opsanus pardus*	liver

TABLE 16. (continued)

LX	3-2-77	Jkt K	sheepshead	muscle
LXI			*Archosargus probatocephalus*	liver
LXII	3-2-77	Jkt N	sheepshead	muscle
LXIII			*Archosargus probatocephalus*	liver
LXIV	3-2-77	Jkt M	sheepshead	muscle
LXV			*Archosargus probatocephalus*	liver

*See Figures 8 and 9.

TABLE 17.

DISTRIBUTION OF n-ALKANES IN FISH SAMPLES

Sample	I	II	III	IV	V	VI	VII
C-12							
C-13							
C-14	2.3						
C-15	41.0		87.5		69.8	16.0	12.1
C-16	4.3				1.9		
C-17	38.3	70.2	12.5		18.9		19.4
C-18	0.8	9.2			2.8	8.0	3.6
C-19	5.1	4.6			1.9	8.0	3.6
C-20	0.8	4.6			1.9	8.0	5.8
C-21	0.4	4.6		100	1.9	12.0	0.5
C-22	0.4	2.3			0.9	8.0	3.6
C-23	2.3	4.6				8.0	5.8
C-24	1.2					8.0	8.2
C-25	1.6					16.0	12.1
C-26	0.8					8.0	8.2
C-27	0.6						12.1
C-28	0.2						4.8
C-29							
C-30							
C-31							
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	VIII	IX	X	XI	XII	XIII	XIV
C-12							
C-13							
C-14			0.8		0.1		
C-15		44.6	89.7	65.7	55.4	20.0	55.2
C-16		0.8	3.1	1.0	0.4	6.7	
C-17	8.0	43.0	0.4	31.4	43.3	46.7	20.7
C-18	8.0	0.8	0.9	1.0	0.1	6.7	3.4
C-19		1.7	3.1	1.0	0.4	6.7	3.4
C-20	8.0	0.8	0.5		0.1	6.7	
C-21	24.0	0.8	0.7		0.1	6.7	3.4
C-22	8.0	0.8	0.1				6.9
C-23	8.0	1.7	0.6		0.2		6.9
C-24	8.0	1.7					
C-25	8.0	1.7	0.1				
C-26	4.0	0.8					
C-27	16.0	0.8					
C-28							
C-29							
C-30							
C-31							
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	XV	XVI	XVI	XVIII	XIX	XX	XXI
C-12							
C-13							
C-14							
C-15	36.3	41.7	79.6	55.3	51.0	45.5	16.7
C-16	0.9	8.3	0.3		2.0	4.5	
C-17	57.4		1.3	1.9	20.4	22.7	37.6
C-18	0.5	8.3	1.3	4.8	2.0	4.5	2.2
C-19	2.5	8.3	2.1	3.4	2.0	2.3	
C-20	0.5	4.2	0.5	3.4	4.1	2.3	
C-21	0.2	4.2	1.1	2.4	2.0		2.2
C-22	0.1	4.2	5.1	3.8	2.0	2.3	2.2
C-23	0.7	4.2	0.5		5.1	2.3	4.4
C-24	0.1	4.2	1.1	0.5	6.1		10.1
C-25	0.5	4.2	1.9	1.0	3.1	9.1	10.1
C-26	0.1	4.2	1.3	1.0		2.3	10.1
C-27	0.1	4.2	1.3	1.4		2.3	4.4
C-28	0 .						
C-29				0.5			
C-30				1.0			
C-31			2.4	1.4			
C-32							
C-33				13.9			
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVIII
C-12							
C-13			0.5	2.1			
C-14	0.2	0.2	1.0	2.4			
C-15	26.2	23.6	12.0	16.4		9.7	
C-16	2.2	2.1	1.9	1.7		9.7	
C-17	27.3	12.9	69.5	32.8	45.5	51.6	3.1
C-18	1.6	2.1	1.6	1.7	9.1	3.2	
C-19	3.3	1.1	2.8	1.7	9.1	6.5	
C-20	1.6	2.1	0.5	1.4	9.1		
C-21	1.1	2.1	0.4	6.3	9.1	6.5	62.5
C-22	1.1	2.1	0.2	1.0	9.1		
C-23	1.6	2.1	0.5	1.7	9.1		3.1
C-24	3.3	4.3	0.7	2.1			3.1
C-25	3.3	8.6	0.9	3.5		6.5	6.3
C-26	3.3	4.3	1.0	2.4			3.1
C-27	3.3	3.2	1.0	1.4		6.5	9.4
C-28	3.3	5.4	1.0	14.6			3.1
C-29	3.3	2.1	1.0	1.7			3.1
C-30	3.3	2.1	0.9	0.7			3.1
C-31	3.3	17.2	0.9	4.2			
C-32	3.3	2.1	0.9				
C-33	2.2		0.4				
C-34	1.1		0.2				
C-35	1.1		0.2				
C-36							
C-37							

TABLE 17. (continued)

Sample	XXIX	XXX	XXXI	XXXII	XXXIII	XXXIV	XXXV
C-12	2.1						
C-13	4.2						
C-14	1.6			0.6			
C-15	40.4		25.2	86.2	3.8		
C-16	8.4	3.7	1.9	3.3	3.8	5.7	7.7
C-17	6.3	3.7	18.9	0.6	80.2	8.6	7.7
C-18	7.4	1.8	1.3	1.5	0.8	5.7	3.8
C-19	6.3	0.9	1.9	3.8	1.9	2.9	
C-20	3.2			0.5			
C-21	2.1			0.3	3.8	22.9	
C-22	0.5		1.9	0.1			
C-23	1.1		4.4	2.1		5.7	
C-24	0.5		10.1	0.1		5.7	
C-25	0.5		10.1	0.4	3.8	8.6	61.5
C-26	0.5		10.1	0.2		5.7	
C-27	0.5	7.3	6.3	0.1	1.9	14.3	
C-28	0.5	12.8	5.0	0.1		8.6	7.7
C-29	10.6	36.7	1.9			2.9	7.7
C-30	0.5	18.3	1.3			2.9	3.8
C-31	2.6	14.7					
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	XXXVI	XXXVII	XXXVIII	XXXIX	XL	XLI	XLII
C-12					0		
C-13							
C-14							
C-15	0.6		6.3			14.3	
C-16	0.6			14.3		14.3	
C-17	1.3	4.5	6.3	85.7		57.1	24.8
C-18	0.3	4.5				14.3	9.9
C-19		4.5					2.0
C-20			12.5				
C-21	74.0						5.9
C-22		2.3	12.5				23.8
C-23			12.5				29.7
C-24	0.6	2.3	12.5				
C-25	1.9	4.5	12.5				2.0
C-26	1.6	4.5	12.5				2.0
C-27	3.2		6.3				
C-28	1.3	72.7	6.3				
C-29	3.2						
C-30	1.9						
C-31	9.1						
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	XLIII	XLIV	XLV	XLVI	XLVII	XLVIII	XLIX
C-12		0					
C-13							
C-14					1.5		
C-15	11.1			1.3	56.7	14.3	33.3
C-16	5.6			1.3	2.2	14.3	16.7
C-17	77.8			3.8	3.0	28.6	16.7
C-18	5.6				1.5	14.3	33.3
C-19					19.4	14.3	
C-20				2.5	1.5		
C-21				21.5	7.5		
C-22				1.3			
C-23				2.5	1.5		
C-24			20.0	2.5			
C-25			20.0	3.8	5.2		
C-26			20.0	5.1			
C-27			20.0	5.1			
C-28			20.0	8.9		14.3	
C-29				31.6			
C-30				8.9			
C-31							
C-32							
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	L	LI	LII	LIII	LIV	LV	LVI
C-12					0		
C-13							
C-14							1.3
C-15			3.3	2.4			31.6
C-16			3.3	2.4			2.5
C-17	12.1		3.3	2.4			
C-18			6.7	2.4			40.5
C-19				2.4			3.8
C-20	5.1	7.7	6.7	2.4			2.5
C-21				2.4			1.3
C-22	10.1	7.7	16.7	7.1			1.3
C-23	12.1	11.5	3.3	9.5			2.5
C-24	20.2	15.4	6.7	11.9			2.5
C-25	12.1	15.4	10.0	14.3		4.5	2.5
C-26	12.1	15.4	10.0	11.9		11.4	2.5
C-27	5.1	7.7	6.7	9.5		2.3	2.5
C-28	5.1	7.7	10.0	9.5		4.5	2.5
C-29	2.0	3.8	6.7	7.1		13.6	
C-30	2.0	3.8	3.3	2.4		59.1	
C-31	2.0	3.8				4.5	
C-32			3.3				
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	LVII	LVIII	LIX	LX	LXI	LXII	LXIII
C-12							
C-13							
C-14						1.1	
C-15	5.3	10.0	2.6	1.6		16.3	3.6
C-16		10.0	2.6	1.6	2.0	5.4	3.6
C-17		5.0		16.4	2.0	21.7	3.6
C-18	8.0	5.0	3.8	8.2	2.0	2.2	
C-19	1.3	5.0	1.3	6.6		2.2	
C-20	2.7		2.6	4.1		1.1	
C-21	60.0	10.0	28.2	1.6	78.4	1.1	76.1
C-22	2.7	10.0	28.2	1.6		1.1	
C-23	4.0	5.0	2.6	1.6		3.3	
C-24	4.0	10.0	3.8	8.2		5.4	
C-25	4.0	20.0	5.1	12.3	3.9	8.7	1.4
C-26	2.7	5.0	2.6	9.8	2.0	5.4	1.4
C-27	1.3	5.0	6.4	8.2	2.0	5.4	1.4
C-28	4.0		5.1	8.2	3.9	6.5	1.4
C-29			5.1	4.1	2.0	4.3	3.6
C-30				4.1	2.0	2.2	3.6
C-31						4.3	
C-32				1.6		2.2	
C-33							
C-34							
C-35							
C-36							
C-37							

TABLE 17. (continued)

Sample	LXIV	LXV
C-12		
C-13		
C-14		
C-15	14.2	
C-16	14.2	
C-17	71.6	
C-18		
C-19		
C-20		
C-21		
C-22		2.5
C-23		8.4
C-24		14.8
C-25		19.0
C-26		18.1
C-27		15.2
C-28		10.5
C-29		6.3
C-30		2.1
C-31		1.3
C-32		
C-33		
C-34		
C-35		
C-36		
C-37		

TABLE 18.

ADDITIONAL ANALYTICAL DATA FOR FISH SAMPLES

Sample	Total n-Alkanes (ppm)	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	1.28	0.04	2.00	8.26
II	2.18	0	0.50	5.21
III	0.08	2.00	0	--
IV	0.30	0	0	--
V	0.53	2.10	0.67	12.3
VI	1.25	--	1.50	1.50
VII	0.21	1.25	2.27	1.86
VIII	1.25	2.00	0	1.78
IX	1.21	0.38	0.50	16.5
X	111	61.56	1.11	17.5
XI	2.10	0.52	1.00	49.0
XII	1260	0	2.50	142
XIII	0.15	0	1.00	3.98
XIV	1.16	0	0.50	8.71
XV	4.36	0.02	1.00	42.5
XVI	0.60	--	4.00	1.99
XVII	3.73	1.40	0	9.41
XVIII	20.8	1.25	0.50	5.90
XIX	0.49	3.50	0	5.17
XX	1.10	1.60	1.00	5.29
XXI	22.8	0	0	3.07
XXII	0.55	0.40	0.67	3.12
XXIII	0.47	0.83	1.00	2.73
XXIV	1.92	0	0.40	8.17
XXV	2.87	0.30	0.40	2.57
XXVI	0.11	0	1.00	2.66
XXVII	0.16	1.63	2.00	6.75
XXVIII	3.20	0	0	7.06
XXIX	3.79	50.0	0.86	2.97
XXX	545	0	0	1.73
XXXI	0.16	0.67	0.50	2.16
XXXII	15.6	81.6	0	14.6
XXXIII	0.26	0.48	2.50	20.7
XXXIV	0.70	1.33	0	1.92
XXXV	0.13	1.50	1.00	3.35
XXXVI	1.54	1.00	2.00	14.9
XXXVII	0.22	0.50	1.00	0.16
XXXVIII	0.16	1.00	0	0.78
XXXIX	0.18	0	0	5.99
XL	0	--	--	--
XLI	0.14	0	0	2.50
XLII	1.01	0	0	1.80
XLIII	0.09	0	0	7.93
XLIV	0	--	--	--
XLV	0.03	--	--	0.67
XLVI	0.79	0	--	2.28
XLVII	0.67	55.5	0.50	13.9

TABLE 18. (continued)

XLVIII	0.07	1.00	0	1.33
XLIX	0.03	0	0	1.00
L	0.05	0	--	0.83
LI	0.07	--	--	0.73
LII	0.30	1.00	1.00	0.50
LIII	0.84	2.00	4.00	1.00
LIV	0	--	--	--
LV	2.20	--	--	0.33
LVI	0.40	--	76.3	0.80
LVII	1.50	--	0.50	3.15
LVIII	0.05	4.00	1.00	1.50
LIX	0.39	--	2.00	1.05
LX	0.12	2.00	1.00	1.11
LXI	2.55	2.00	1.00	7.40
LXII	0.92	0.75	1.50	2.07
LXIII	1.38	1.00	--	9.00
LXIV	0.88	1.00	--	6.04
LXV	23.7	0	--	1.08

TABLE 19.

TABULATION OF BENTHIC ORGANISMS

Sample	Date	Location*	Species	Collection method
I	2-16-77	Pfm A	brittle worm (*Chloeia viridis*)	trap
II	3-2-77	Jkt K	sea urchin (*Arbacia unctulata*)	diver

*See Figure 8.

TABLE 20.

DISTRIBUTION OF n-ALKANES IN BENTHIC ORGANISMS

Sample	I	II
C-12		
C-13		
C-14		
C-15		
C-16		1.5
C-17	0.5	
C-18	0.3	1.5
C-19	1.0	20.9
C-20	11.0	1.5
C-21	64.2	44.8
C-22	20.1	1.5
C-23	0.5	1.5
C-24	0.5	3.0
C-25	0.5	3.0
C-26	0.5	3.0
C-27	0.5	4.5
C-28	0.5	9.0
C-29		4.5
C-30		
C-31		
C-32		
C-33		
C-34		
C-35		
C-36		
C-37		

TABLE 21.

ADDITIONAL ANALYTICAL DATA FOR BENTHIC ORGANISMS

Sample	Total n-Alkanes (ppb)	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	998	0	0	2.05
II	670	--	0.50	3.76

TABLE 22.

TABULATION OF SEDIMENT SAMPLES

Sample	Date	Location*	Collection method
I	6-5-76	21	core
II	6-5-76	31	core
III	6-5-76	104	core
IV	6-5-76	105	core
V	6-5-76	105	grab
VI	6-5-76	107	core
VII	6-5-76	108	core
VIII	6-10-76	11	core
IX	6-10-76	13	core
X	6-10-76	40	core
XI	6-10-76	62	core
XII	6-10-76	69	core
XIII	6-10-76	70	core
XIV	6-10-76	96	core
XV	6-10-76	97	core
XVI	6-10-76	98	grab
XVII	6-10-76	99	core
XVIII	6-10-76	100	core
XIX	6-11-76	32	core
XX	6-11-76	61	core
XXI	6-11-76	63	core
XXII	6-11-76	67	core
XXIII	6-11-76	71	core
XXIV	6-11-76	73	core
XXV	6-11-76	74	core
XXVI	6-11-76	76	core
XXVII	6-11-76	77	core
XXVIII	6-11-76	78	core
XXVIX	6-11-76	80	core
XXX	6-11-76	81	core
XXXI	6-11-76	82	core
XXXII	6-11-76	83	grab
XXXIII	6-11-76	84	core
XXXIV	6-11-76	85	core
XXXV	6-11-76	92	core
XXXVI	6-11-76	101	core
XXXVII	6-11-76	102	core
XXXVIII	6-11-76	110	core
XXXIX	6-12-76	38	core
XL	6-12-76	39	core

TABLE 22. (continued)

Sample	Date	Location*	Collection method
XLI	6-12-76	86	core
XLII	6-12-76	87	grab
XLIII	6-12-76	89	grab
XLIV	6-12-76	91	grab
XLV	6-12-76	94	core
XLVI	7-1-76	6	core
XLVII	7-1-76	17	core
XLVIII	7-2-76	18	core

*See Figure 3.

TABLE 23.

DISTRIBUTION OF n-ALKANES IN SEDIMENT SAMPLES

Sample	I	II	III	IV	V	VI	VII
C-12	2.2		2.3	4.3			
C-13	0.4		6.0				
C-14	17.7		2.7	17.6		1.0	0.1
C-15	3.0	2.8	1.7	2.6		5.0	0.3
C-16	0.7	2.8	0.6	2.6		5.0	0.7
C-17	5.6	6.1	1.4	6.4		10.1	
C-18	0.6	2.8	0.5	1.3		3.0	0.2
C-19		2.2	0.1	1.0		3.0	0.1
C-20	5.8	1.1				1.5	
C-21	0.3	9.4	0.5	6.1		17.1	1.0
C-22	1.4	1.1	0.4	0.8		1.0	0.3
C-23	1.7	2.8	1.1	1.3		2.0	0.9
C-24	4.6	1.1	2.4	1.5		1.0	3.2
C-25	6.1	5.0	6.5	4.1		5.0	8.2
C-26	8.9	3.3	7.8	4.1		4.0	12.2
C-27	7.1	8.3	12.2	7.4		7.0	14.7
C-28	11.0	4.4	10.4	5.1		1.0	13.6
C-29	4.8	15.0	13.6	10.1		16.1	13.6
C-30	8.9	2.2	8.0	2.8		3.0	9.9
C-31	3.2	16.7	10.7	10.5		13.1	9.6
C-32	3.9	2.8	3.7	2.8		1.0	4.6
C-33	0.9	10.0	4.9	6.4			4.0
C-34	1.3		1.2				1.6
C-35			1.3	1.3			1.3
C-36							
C-37							

TABLE 23. (continued)

Sample	VIII	IX	X	XI	XII	XIII	XIV
C-12	12.9	16.7	0.3	5.8	5.3		
C-13	3.5	3.5	0.5	7.5			
C-14		0.4	0.3	1.7		0.6	
C-15	5.8	3.5	1.7	4.2	2.3	4.8	7.2
C-16	2.3	1.8	1.7	4.2	1.6	2.4	5.2
C-17	20.0	28.6	3.5	20.8	17.8	10.7	10.3
C-18	4.7	1.8	2.4	4.2	1.6	3.6	3.1
C-19	7.0	4.4	1.0	16.7	5.4	6.0	5.2
C-20			0.3				
C-21	5.8	4.4	7.3	8.3	2.3	2.4	
C-22		0.4	0.3			0.6	
C-23			1.0			1.2	
C-24	1.2	0.9	2.4		2.3	2.4	
C-25	4.7	3.5	7.0	3.3	7.0	4.8	5.2
C-26	2.3	2.6	8.4	2.5	9.3	3.6	3.1
C-27	7.0	6.7	11.8	5.0	14.7	7.1	7.2
C-28	2.3		9.1	1.7	6.2	2.4	4.1
C-29	1.2	7.9	13.2	5.8	10.1	11.9	10.3
C-30			5.6		5.4	7.1	3.1
C-31	9.4	7.9	10.1	5.8	7.8	9.5	10.3
C-32	2.3		3.5		1.6	9.5	
C-33	3.5	2.6	5.9	2.5	2.3	6.0	3.1
C-34	1.2	0.4	0.7			1.2	
C-35	2.9	1.8	1.7			2.4	3.1
C-36		0.4					
C-37							

TABLE 23. (continued)

Sample	XV	XVI	XVII	XVIII	XIX	XX	XXI
C-12					11.2		11.1
C-13				3.4	6.9		3.7
C-14				0.7	1.7		
C-15				4.0	4.3		1.8
C-16			4.3	2.7	4.3		1.8
C-17	33.3	40.0	32.2	20.1	19.8	25.8	14.8
C-18	33.3	13.3	6.1	5.4	4.3	25.8	3.0
C-19			8.7	4.0	17.2	6.5	5.0
C-20		6.7	2.6				
C-21			8.7	5.4	3.4	6.5	
C-22	33.3		2.6	0.7		6.5	
C-23			2.6	1.3			
C-24			2.6	1.3		12.9	1.8
C-25			4.3	5.4			7.4
C-26			2.6	4.0	1.7		8.9
C-27			6.1	8.7	4.3		14.8
C-28		6.7	11.3	1.3	8.6		11.1
C-29		26.7		0.7	9.5		3.7
C-30		6.7		6.7		16.1	
C-31				12.1			3.7
C-32			5.2	2.7			3.7
C-33				5.4			3.7
C-34				0.7			
C-35				3.4			
C-36							
C-37							

TABLE 23. (continued)

Sample	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVIII
C-12	22.9						1.1
C-13	2.8						5.6
C-14	0.7			0.3			0.6
C-15	2.8	5.7		2.6			3.9
C-16	1.7	5.7		3.9			3.4
C-17	11.1	30.0		6.5			15.7
C-18	1.4	5.7		3.9			4.5
C-19	9.7	5.7		2.6			2.8
C-20				0.3			2.2
C-21	3.5	7.1	2.8	10.4	7.8	1.8	4.5
C-22	0.7	1.4	1.9	1.0		2.9	1.1
C-23			2.8	1.6		4.2	2.2
C-24	1.0	1.4	4.8	1.6	1.9	5.9	1.7
C-25	2.8	8.6	7.6	5.2	7.8	10.7	5.6
C-26	2.1	7.1	8.5	5.5	5.6	9.4	3.4
C-27	5.6	11.4	10.4	9.1	11.1	11.3	7.9
C-28	2.1		11.3	8.1	9.4	10.1	1.1
C-29	8.3	2.9	10.4	11.7	13.0	10.7	12.4
C-30			7.6	4.5	3.3	6.5	
C-31	7.6	2.9	10.4	10.4	14.8	10.7	9.0
C-32	3.5	1.4	8.5	5.8	9.4	5.9	3.4
C-33	3.5	2.9	8.7	4.5	9.4	5.9	4.5
C-34	0.7		3.7	0.6	3.3	2.3	
C-35	5.6		2.8		3.3	1.8	3.4
C-36			0.9				
C-37							

TABLE 23. (continued)

Sample	XXIX	XXX	XXXI	XXXII	XXXIII	XXXIV	XXXV
C-12		7.8					
C-13		2.2					
C-14		0.5				1.3	
C-15		1.9			5.1	5.4	
C-16		1.2			14.3	6.7	
C-17		7.6			20.4	37.6	19.0
C-18		1.5			14.3	4.0	19.0
C-19		1.7			5.1	12.1	
C-20	2.5					0.7	4.8
C-21	24.1	2.4	14.1	20.5		6.7	9.5
C-22	2.5				2.0	0.7	4.8
C-23	2.5				2.0		
C-24	2.5	3.2	3.3		2.0	1.3	
C-25	5.8	10.3	3.3	7.7	14.3	6.7	
C-26	3.3	13.2	3.3	2.6	2.6	4.0	
C-27	11.6	13.7	14.1	15.4	2.6	8.1	
C-28	12.5	14.3	14.1	15.4	10.2		9.5
C-29	7.5	8.4	6.7	10.3	2.6	2.7	19.0
C-30	2.5	3.9	6.7	2.6	2.6		9.5
C-31	10.0	3.9	14.1	12.8		2.0	4.8
C-32	7.5		6.7	7.7			
C-33	5.1	1.3	6.7	5.1			
C-34		0.3	3.3				
C-35		0.8	3.3				
C-36							
C-37							

TABLE 23. (continued)

Sample	XXXVI	XXXVII	XXXVIII	XXXIX	XL	XLI	XLII
C-12	34.9		15.6				3.7
C-13	1.6		5.2	4.3	6.0	0.9	1.4
C-14	0.8		0.6		2.0		18.2
C-15	3.2	2.4	4.5	4.3	10.0	1.5	3.7
C-16	4.0	3.1	5.2	2.9	10.0	1.5	2.0
C-17	19.0	26.8	18.2	8.6	16.0	6.1	6.4
C-18	3.2	9.4	5.2	2.9	4.0	1.5	1.1
C-19	6.3	0.8	6.5	2.9	8.0		0.4
C-20							
C-21	4.8	4.7	3.9	15.7		7.6	6.7
C-22			0.6	1.4			0.7
C-23				1.4		1.5	1.2
C-24	0.8	0.8	1.3	1.4		1.5	1.6
C-25	4.0	3.1	3.9	5.7	4.0	6.1	3.9
C-26	3.2	3.9	2.6	4.3	20.0	9.1	4.2
C-27	4.0	7.9	6.5	5.7	8.0	12.2	7.1
C-28	4.0			7.1	6.0	12.2	5.5
C-29	6.3	19.7	6.5	8.6	8.0	12.2	9.3
C-30				1.4		4.6	3.9
C-31		15.7	7.8	8.6	8.0	9.1	8.2
C-32				4.3	4.0	4.6	2.3
C-33		1.6	2.6	4.3	4.0	3.0	5.0
C-34				2.9		1.5	0.9
C-35			3.2	1.4		1.5	1.8
C-36						1.5	
C-37							

TABLE 24.

TABULATION OF MISCELLANEOUS SAMPLES

Sample	Date	Type	Origin
I	10-3-76	vessel fuel	Gus III

TABLE 25.

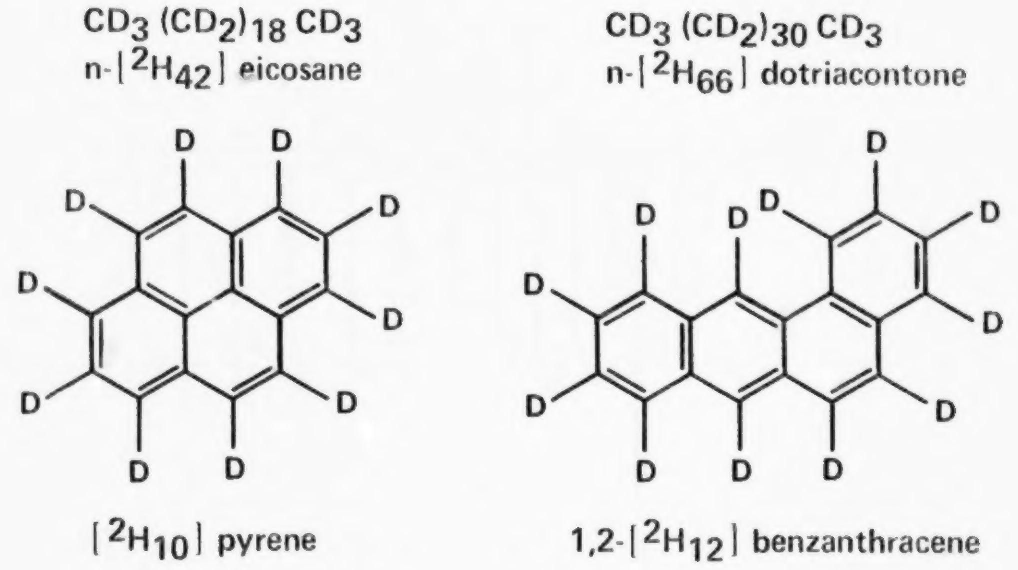
DISTRIBUTION OF n-ALKANES IN MISCELLANEOUS SAMPLES

Sample	I
C-12	
C-13	5.4
C-14	2.7
C-15	4.5
C-16	3.6
C-17	30.4
C-18	21.4
C-19	16.1
C-20	8.9
C-21	4.4
C-22	1.9
C-23	0.4
C-24	0.2
C-25	0.2
C-26	
C-27	
C-28	
C-29	
C-30	
C-31	
C-32	
C-33	
C-34	
C-35	
C-36	
C-37	

TABLE 26.

ADDITIONAL ANALYTICAL DATA FOR MISCELLANEOUS SAMPLES

Sample	Total n-Alkanes	Pristane/ n-C-17	Phytane/ n-C-18	Odd/Even Preference
I	12.3%	0.62	0.42	1.58



$CD_3(CD_2)_{18}CD_3$
n-[$^2H_{42}$] eicosane

$CD_3(CD_2)_{30}CD_3$
n-[$^2H_{66}$] dotriacontone

[$^2H_{10}$] pyrene

1,2-[$^2H_{12}$] benzanthracene

Structures of Deuteriated Internal Standards Employed for Quantitation

Fig. 1. Structure of deuteriated internal standards employed for quantitation

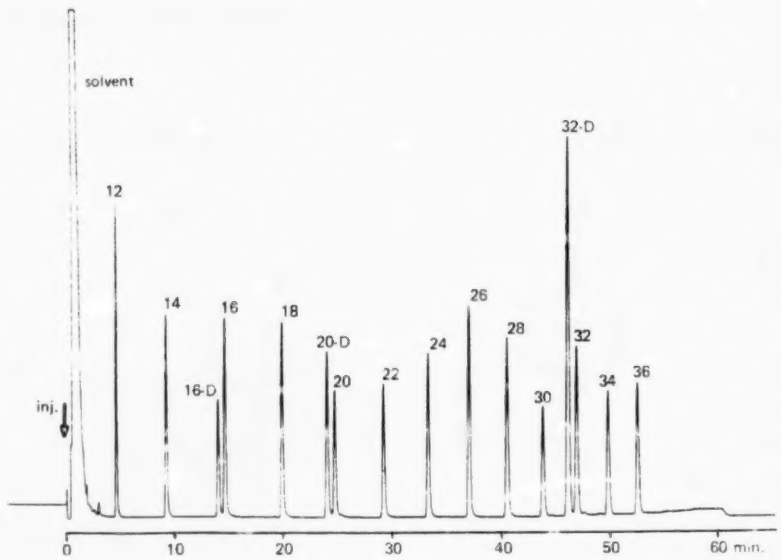
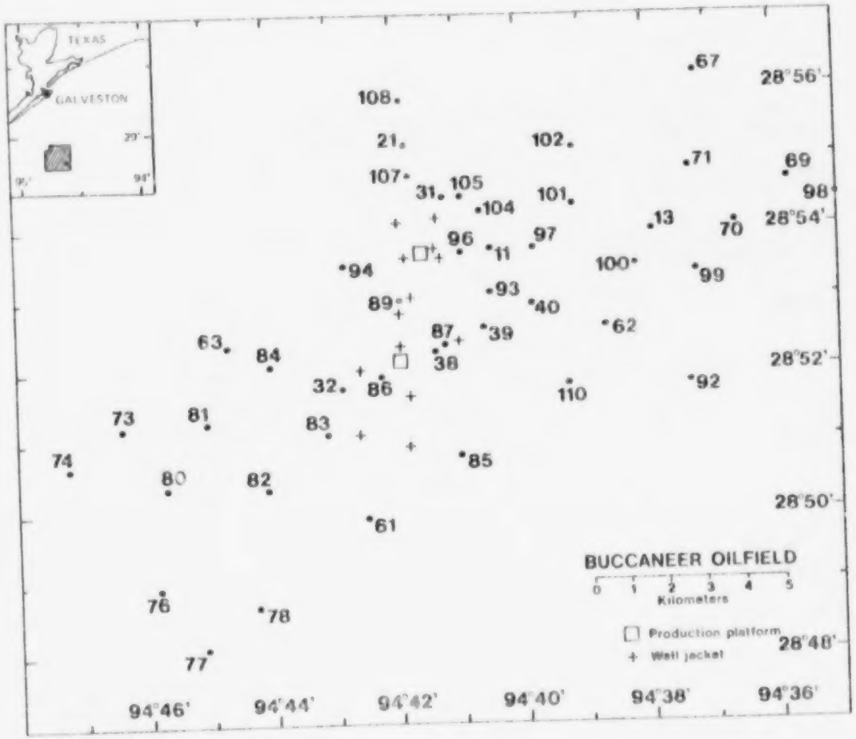


Fig. 2. Gas chromatogram showing separation of n-[$^2H_{34}$]hexadecane (16-D), n-[$^2H_{42}$]eicosane (20-D), and n-[$^2H_{66}$]dotriacontane (32-D) from n-alkanes $C_{12}H_{26}$ (12) to $C_{36}H_{74}$ (36)



TEXAS
GALVESTON
29°
95°
94°
BUCCANEER OILFIELD
0 1 2 3 4 5
Kilometers
Production platform
Well jacket
28°56'
28°54'
28°52'
28°50'
28°48'
94°46'
94°44'
94°42'
94°40'
94°38'
94°36'
108
21
107
31
105
104
102
101
96
11
97
94
89
93
40
87
39
63
84
38
32
86
73
81
83
74
80
82
85
61
76
78
77
67
71
69
98
13
70
100
99
62
92
110

Fig. 3. Locations of standard sample collection stations (some sediment and water samples)

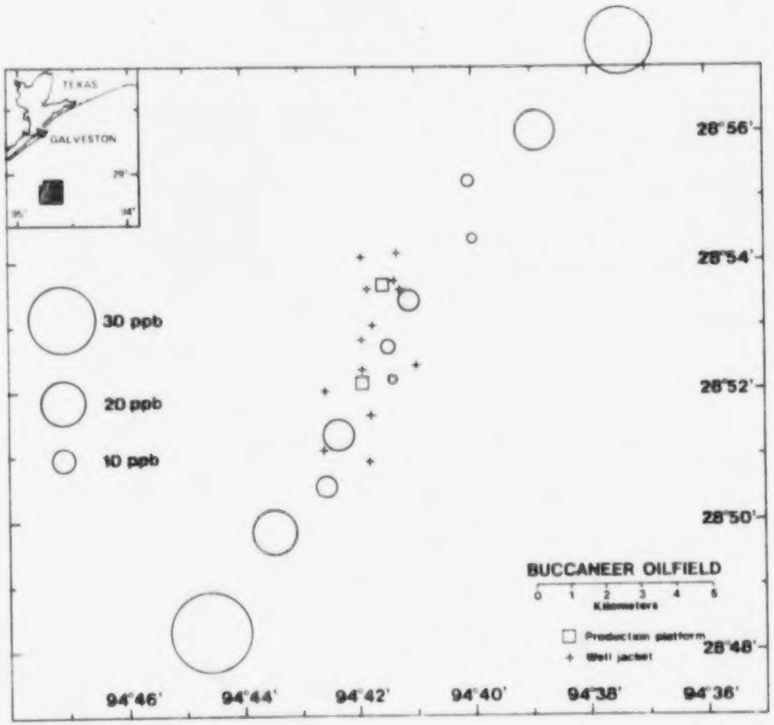

TEXAS
GALVESTON
29°
95°
94°
30 ppb
20 ppb
10 ppb
28°56'
28°54'
28°52'
28°50'
28°48'
94°46'
94°44'
94°42'
94°40'
94°38'
94°36'
BUCCANEER OILFIELD
0 1 2 3 4 5
Kilometers
□ Production platform
+ Well jacket

Fig. 4. Total n-alkanes in surface water samples, August 31 - September 1, 1976

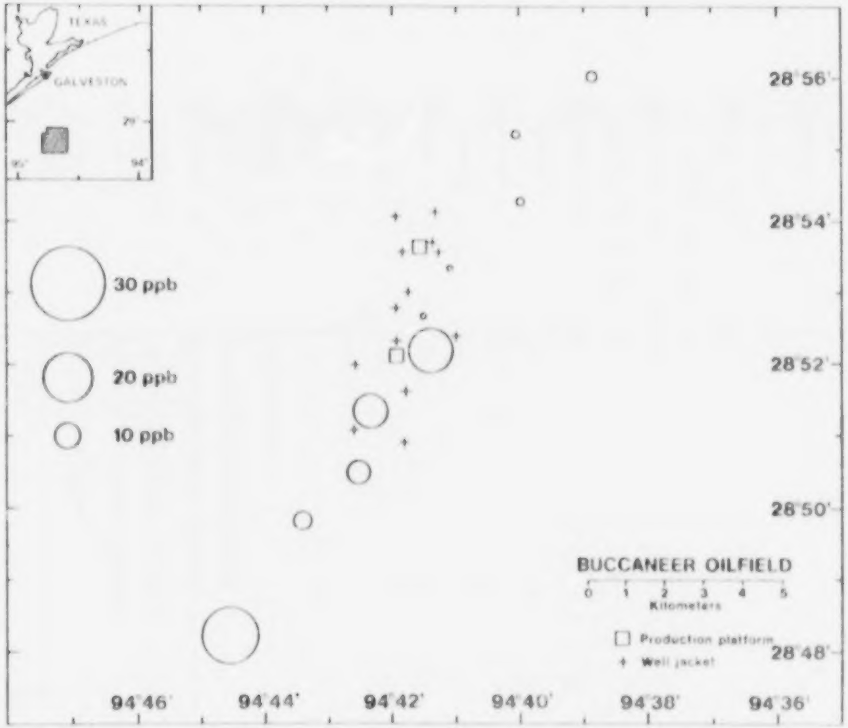

TEXAS
GALVESTON
29°
95°
94°
30 ppb
20 ppb
10 ppb
28°56'
28°54'
28°52'
28°50'
28°48'
BUCCANEER OILFIELD
0 1 2 3 4 5
Kilometers
□ Production platform
+ Well jacket
94°46'
94°44'
94°42'
94°40'
94°38'
94°36'

Fig. 5. Total n-alkanes in bottom water samples, August 31 - September 1, 1976

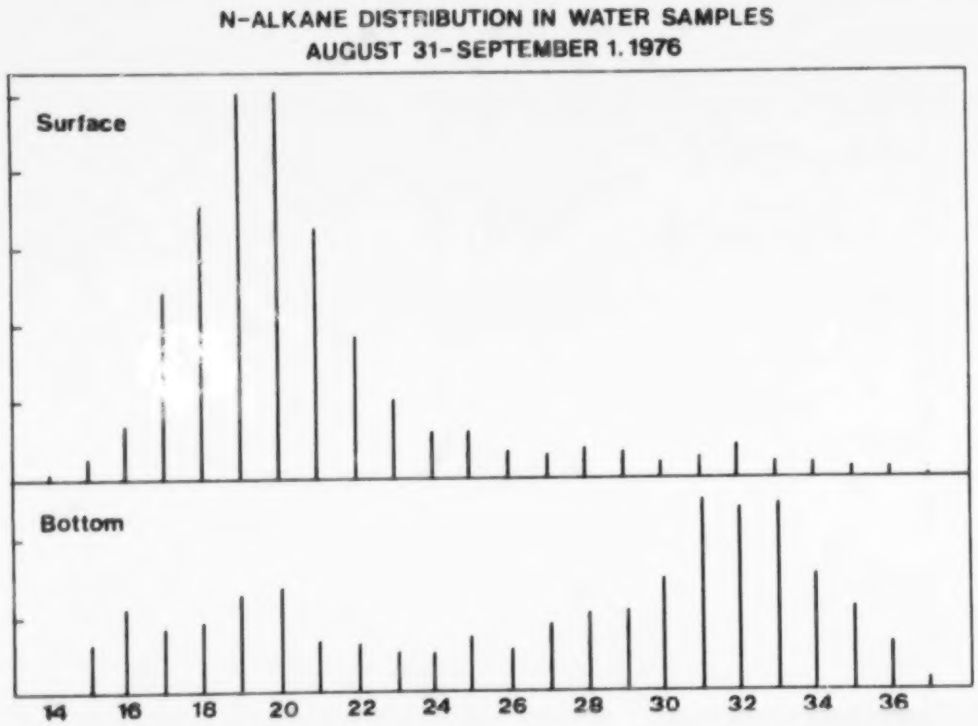


Fig. 6. n-Alkane distibution in surface and bottom water samples. August 31 - September 1, 1976

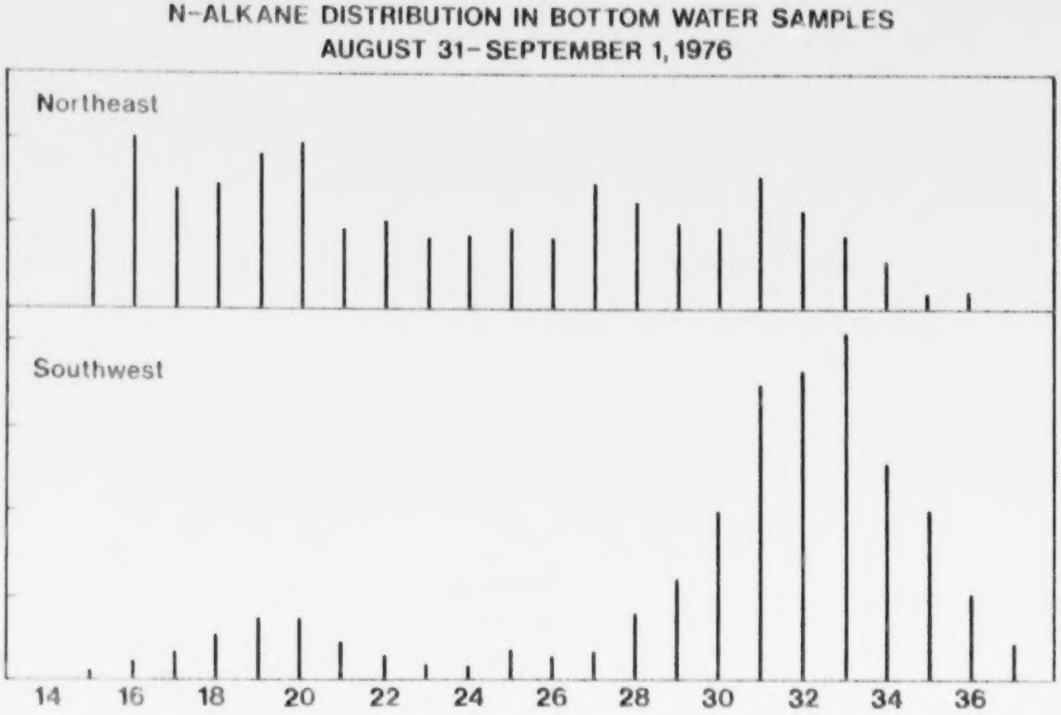


Fig. 7. n-Alkane distribution in bottom water samples Northeast and Southwest of the oilfield, August 31 - September 1, 1976

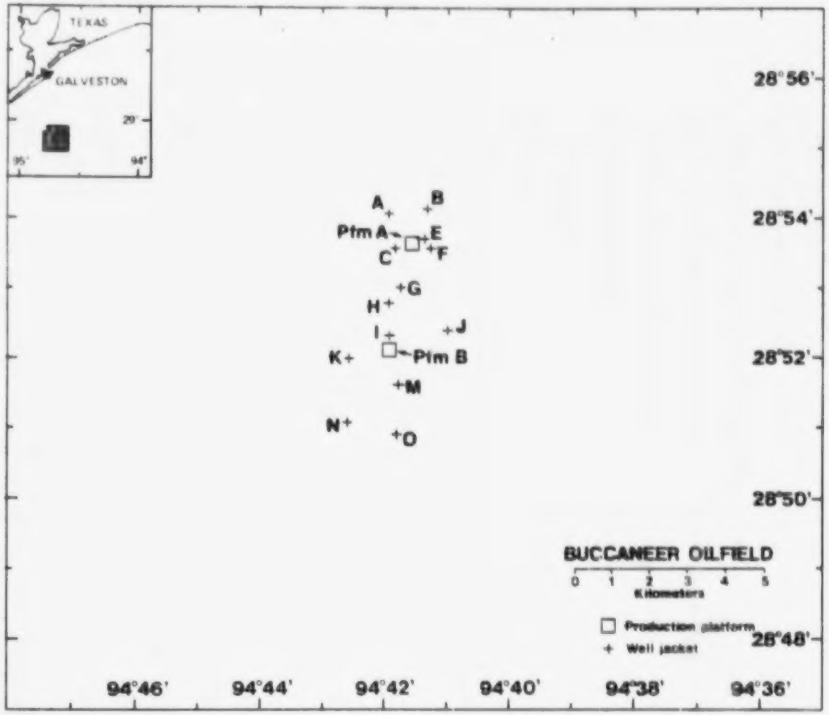
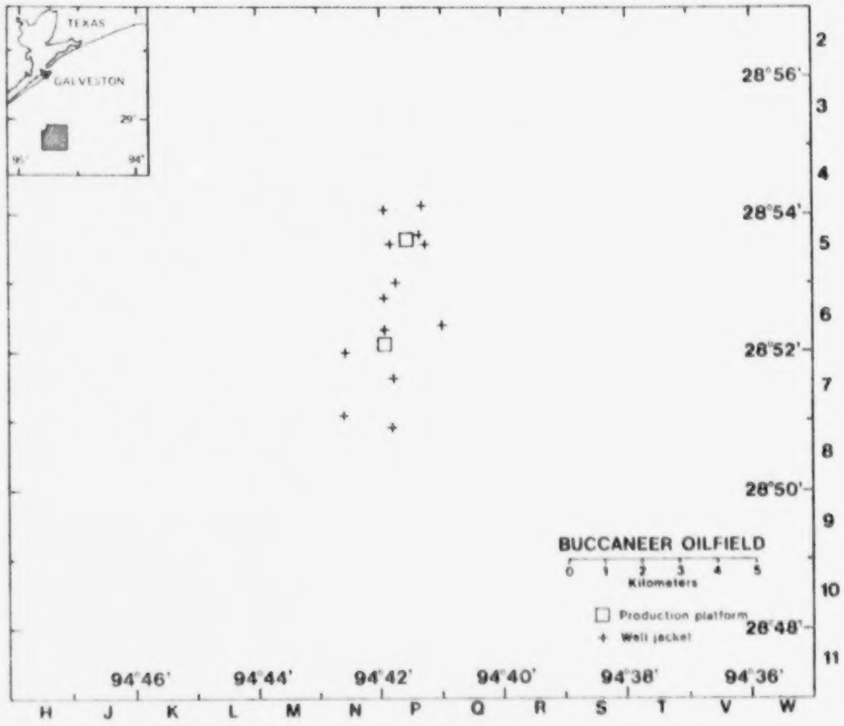

TEXAS
GALVESTON
29°
95°
94°
A
B
Ptm A
E
C
F
G
H
I
J
K
Ptm B
M
N
O
28°56'
28°54'
28°52'
28°50'
28°48'
BUCCANEER OILFIELD
0 1 2 3 4 5
Kilometers
Production platform
Well jacket
94°46'
94°44'
94°42'
94°40'
94°38'
94°36'

Fig. 8. Locations of structures



TEXAS
GALVESTON
29°
95°
94°
BUCCANEER OILFIELD
0 1 2 3 4 5
Kilometers
□ Production platform
+ Well jacket
28°56'
28°54'
28°52'
28°50'
28°48'
94°46'
94°44'
94°42'
94°40'
94°38'
94°36'
2
3
4
5
6
7
8
9
10
11
H
J
K
L
M
N
P
Q
R
S
T
V
W

Fig. 9. Alphanumeric grid locations

TOTAL ORGANIC CARBON AND CARBON ISOTOPES OF SEDIMENTS

PRINCIPAL INVESTIGATOR

E. William Behrens

EXECUTIVE SUMMARY

The purpose of this study is to determine the extent of pollution of the total organic carbon in sediments affected by an active oil field by comparison to an unaltered area. The measure for determining the effect of oil field activity is the carbon isotopic characteristics of the total organic carbon. If pollution has occurred, it should render the stable carbon isotope ratio more negative than in normal marine sediments and radiocarbon ages anomalously old in affected areas.

The results show a pattern of somewhat more negative stable carbon isotope ratios that occurs through both the field and in surrounding sediments. The negative values are somewhat more abundant in the surficial sediments than deeper in cores. Radiocarbon ages show a slow rate of sedimentation (0-2 cm/100 years). Older ages definitely occur nearer the field. These may be attributed to scour of younger sediments near producing structures, but sedimentation rates suggest some addition of dead carbon also.

The total organic carbon content distribution shows a high in the northern part of the field, but no significant correlation supporting a model that would have more negative stable carbon isotope ratios and older radiocarbon ages caused by addition of hydrocarbons or associated organic carbon pollutants. The isotopic distribution pattern suggests that such pollution has occurred, but does not have a distribution pattern consistent with the simple model tested.

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INTRODUCTION

This research project addresses the question: do the isotopes of carbon in the organic matter of the sediments within the Buccaneer Field indicate that any alteration of sedimentary organic matter has resulted from drilling and producing operations?

Such an effect should be detectable, because the stable carbon isotope ratio ($\delta^{13}C$) is commonly more negative in hydrocarbons and older producing formation sedimentary organic carbon than in modern marine organic matter. The average $\delta^{13}C$ for 168 samples from the Texas continental shelf is -20.1 (Plucker, 1970, Gearing, 1975), whereas crude oil from the Buccaneer Field is -30.8.

In addition to a distinctive $\delta^{13}C$, older organic carbon would be devoid of ^{14}C, and any contribution of it to younger organic matter would produce anomalously old radiocarbon ages. A contribution of carbon with no ^{14}C might also be detectable in very modern surficial sediment containing the distinctive positive $\delta^{14}C$ anomaly which resulted from the addition of an excessive amount of ^{14}C created by nuclear device testing. This anomaly began to be detected in the marine environment in the early 1950's.

This predictive model of the effect of the addition of Buccaneer Field hydrocarbon or older sedimentary carbon to the modern marine sediments in or near the field is depicted in Figure 1.

MATERIALS AND METHODS

Visual examination of the cores sampled revealed that surficial sediments are generally shelly sands or shelly, muddy sands and only rarely muds. There is a tendency for a slight increase in muddiness with depth in cores. Inshore to the northwest and to the north of the field the bottom commonly consists of shell beds. Eastnortheastward, on the other hand, the sediment is much muddier and more regularly laminated indicating less disturbance by burrowing organisms than has occurred in the muddy sands within the field. Control areas with sediments most like those within the field are offshore and to the southwest.

Beneath the Holocene muddy sands lies the Beaumont Formation. It is distinctively clayey in texture and is either medium to dark grey or strongly stained with brown to yellow bands and laminae of iron oxides.

Samples of the marine sediments were removed from short cores (up to 20 cm) taken in connection with the sedimentology work unit of this study program (done by J. B. Anderson of Rice University) and from longer piston cores taken as a part of this work unit.

The locations of the Rice University short cores are shown as the sam-

PREDICTION MODEL FOR CARBON ISOTOPE DISTRIBUTION

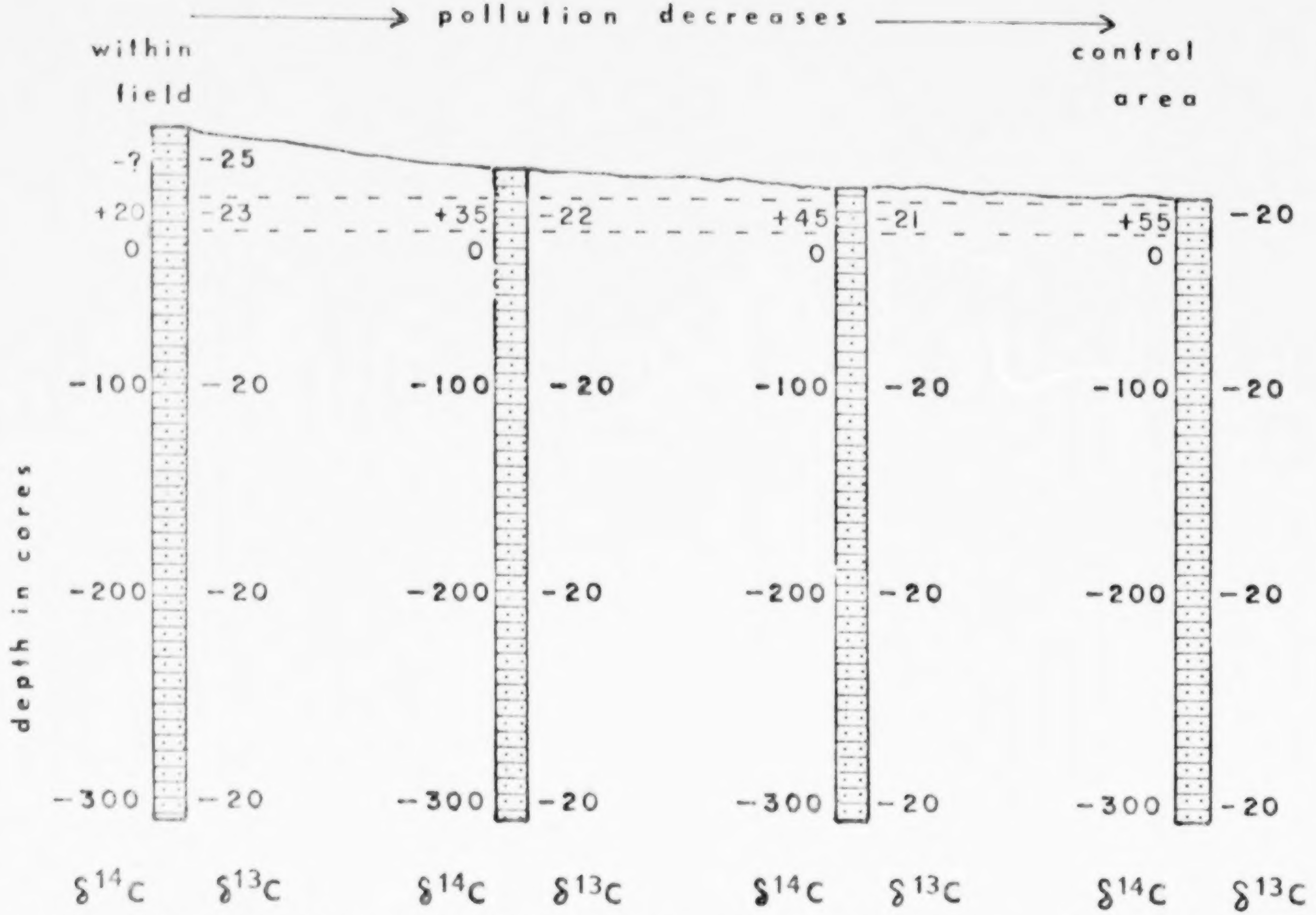

pollution decreases
within field
control area
depth in cores
-?
+20
0
-100
-200
-300
-25
-23
-20
-20
-20
+35
0
-100
-200
-300
-22
-20
-20
-20
+45
0
-100
-200
-300
-21
-20
-20
-20
+55
0
-100
-200
-300
-20
-20
-20
-20
$\delta^{14}C$
$\delta^{13}C$
$\delta^{14}C$
$\delta^{13}C$
$\delta^{14}C$
$\delta^{13}C$
$\delta^{14}C$
$\delta^{13}C$

Figure 1. Predicted distribution of carbon isotopes in sediments assuming sedimentation near oil field structures contains polluting hydrocarbons or other organic matter from producing formations (uppermost unit in cores). The unit between dashed lines contains excessive ^{14}C from nuclear testing. Relative isotopic values are more significant than absolute values.

pling stations on Figures 2 and 4 . The piston cores were taken on transects north, east, south, and west from Platform A at distances of 15 m (50 feet), 53 m (175 feet), 76 m (250 feet), 152 m (500 feet), and some at 460 m (¼ mile), 910 m (½ mile), and 1.8 km (1 mile). Three cores were taken at most stations. Four piston cores were also taken in each of four control areas located northwest (inshore), northeast (area X), southeast (offshore), and southwest (area Y) and at distances of about 4 km from the field.

The selected sediment samples were acidified in HCl to remove carbonate, diluted and decanted to remove excess salts, dried at less than 50°C, and powdered. The powdered samples were then combusted with oxygen to obtain CO_2 for total organic carbon measurement (manometrically) and for isotopic analyses. Radiocarbon dating requires much more material than the other types of analyses, so samples from short intervals (4 to 5 cm) were taken from equivalent depths in several of the replicate cores at each station for this purpose. Results are reported as uncorrected radiocarbon years before present (B.P.).

RESULTS

All results are tabulated in the Appendix.

Total Organic Carbon Total organic carbon (TOC) content of the sediments in the study area is low ranging from less than 0.1% to just under 1%. The mean of 220 analyses is 0.33%. Most of the samples with over 0.4% TOC are either from the muddier control area to the northeast of the field (area X) (mean of 35 samples = 0.51%) or from the Beaumont Formation (mean of 8 samples = 0.51%). Consequently the mean value for samples within the field and in comparable control areas is only 0.29% and rarely occurs outside the range of 0.15 to 0.42%.

The areal distribution of the TOC values (Figure 2) shows two areas of relatively high carbon concentrations. One is in the eastnortheast corner of the study area which geophysical evidence indicates is a down-faulted block which contains muddier and less bioturbated sediment than that in the field and to the southeast, south, and southwest as described earlier. The other area is at the north end of the field.

Stable Carbon Isotopes The frequency distribution of 217 $\delta^{13}C$ measurements is shown in Figure 3 . The most negative tail of this distribution contains eight samples of Beaumont sediment which have a mean $\delta^{13}C$ of -22.7. The tail on the left side of the distribution consists of 19 samples with $\delta^{13}C$ more positive than -20.0.

The $\delta^{13}C$ values of the bulk of the samples fall between -20.0 and -21.3 and have a distinctively bimodal distribution. The areal distribution of the two modes is shown in Figure 3 . Although there are two major concentrations of the more negative mode near or in the field, several smaller occurrences

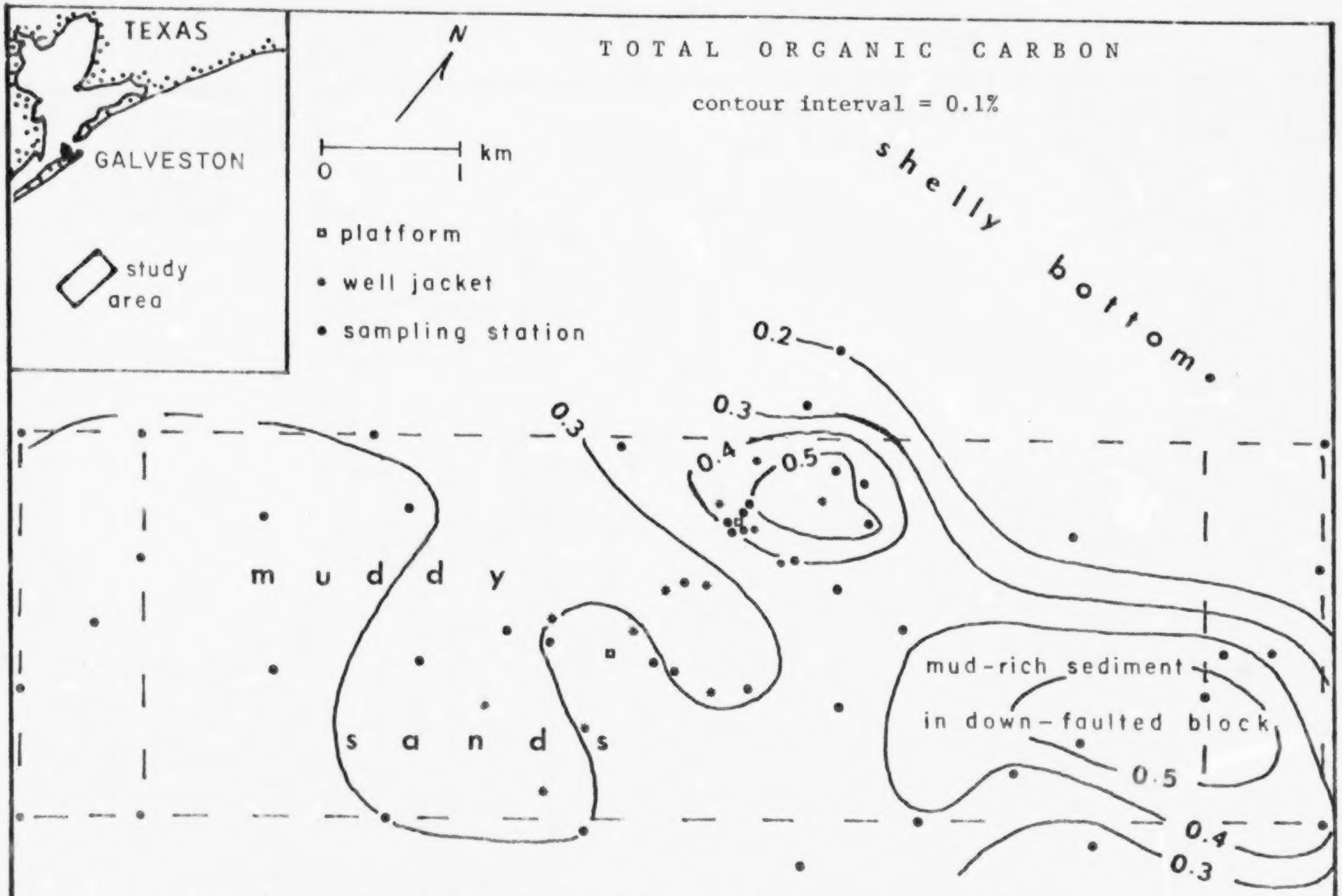
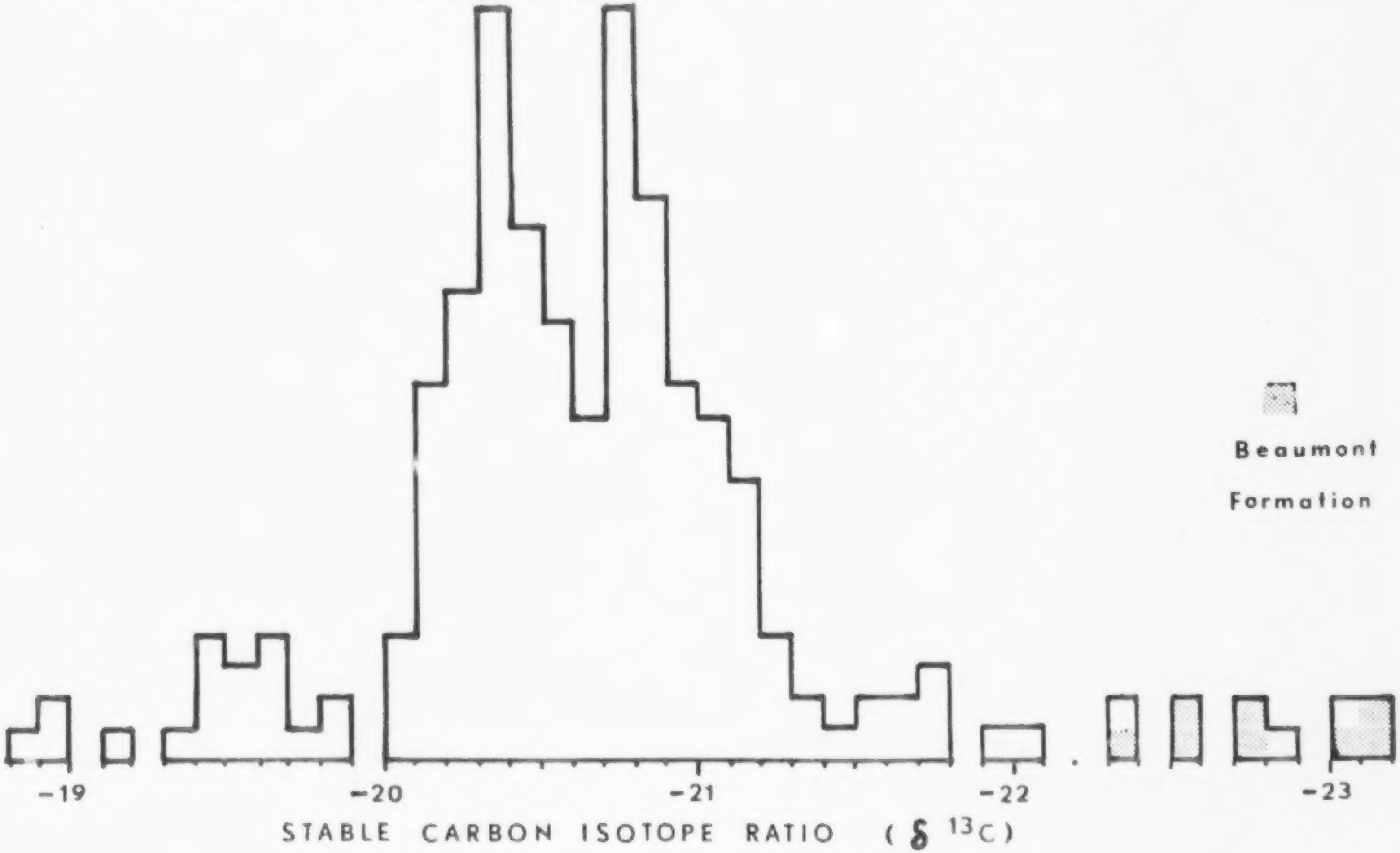

TEXAS
GALVESTON
study area
N
0
1
km
▫ platform
• well jacket
• sampling station
TOTAL ORGANIC CARBON
contour interval = 0.1%
shelly bottom.
muddy sands
mud-rich sediment in down-faulted block
0.2
0.3
0.3
0.4
0.5
0.5
0.4
0.3

Figure 2. Total organic carbon in surficial sediments (upper 2 cm).

Figure 3. Frequency distribution of stable carbon isotope values for 217 samples of sediment in and near Buccaneer Oil Field.



of it suggest it is distributed well beyond the limits of the field (Figure 4).

In three dimensions no strong tendency in $\delta^{13}C$ distribution is evident except that positive values predominate in the lowest part of the Holocene near the Beaumont contact (mean of 14 samples = -20.12). Data from one core suggests that the apparently erratic distribution of $\delta^{13}C$ values may be due to sampling cores discontinuously. Core 56 from the southwest control area was sampled continuously at 4 cm intervals and shows a smooth transition from the positive mode at the surface to a negative peak at about 30 cm depth and then back to the center of the negative mode below 50 cm (Appendix, samples 179-194).

Radiocarbon Most radiocarbon dates were obtained on the disseminated total organic carbon in the sediments. Eight shell dates taken for comparison show a range of only 1,100 years and average 4,200 B.P. Most of these were from the inshore control area to the northwest of the field. These dates show inconsistencies of decreasing age with depth. Only TOC dates were used for analysis of the results.

Four dates from a core in the northeast control area (X) also give inconsistent results from TOC. Three of the four samples have essentially the same age (10,860 to 11,540 B.P.) although coming from depths of 25 to 75 cm in the cores.

Two dates on the Beaumont Formation are 22,112 and 24,810 B.P. which confirm that this formation is Pleistocene in age.

The oldest Holocene sediments lying just above the Beaumont contact date at about 12,000 B.P. The average rate of deposition for Holocene sediments based on 21 pairs of dates is 0.1 mm/year. However, the rates decline systematically upward in the cores. Sedimentation rates are also less within the field than in the control area to the southeast (offshore).

INTERPRETATIONS

Due to differences in sediment characteristics, the areas to the northwest (inshore) and northeast (area X) should not be used as controls for comparison with conditions within the Buccaneer Oil Field. Organic carbon comparisons strongly support this, because TOC content is anomalously low in the shellier and anomalously high in the muddier sediments occurring in those areas. Both areas have inconsistent radiocarbon age sequences within cores and have somewhat erratic stable carbon isotope distributions.

From the radiocarbon ages and calculated rates of deposition the thickness of sediment containing the predicted positive $\delta^{14}C$ anomaly in the control area would be less than 3/4 mm, and thus it is not detectable. Furthermore, there is no evidence that this material was even deposited, because if it had been, it should have affected the most recent date by making it appear

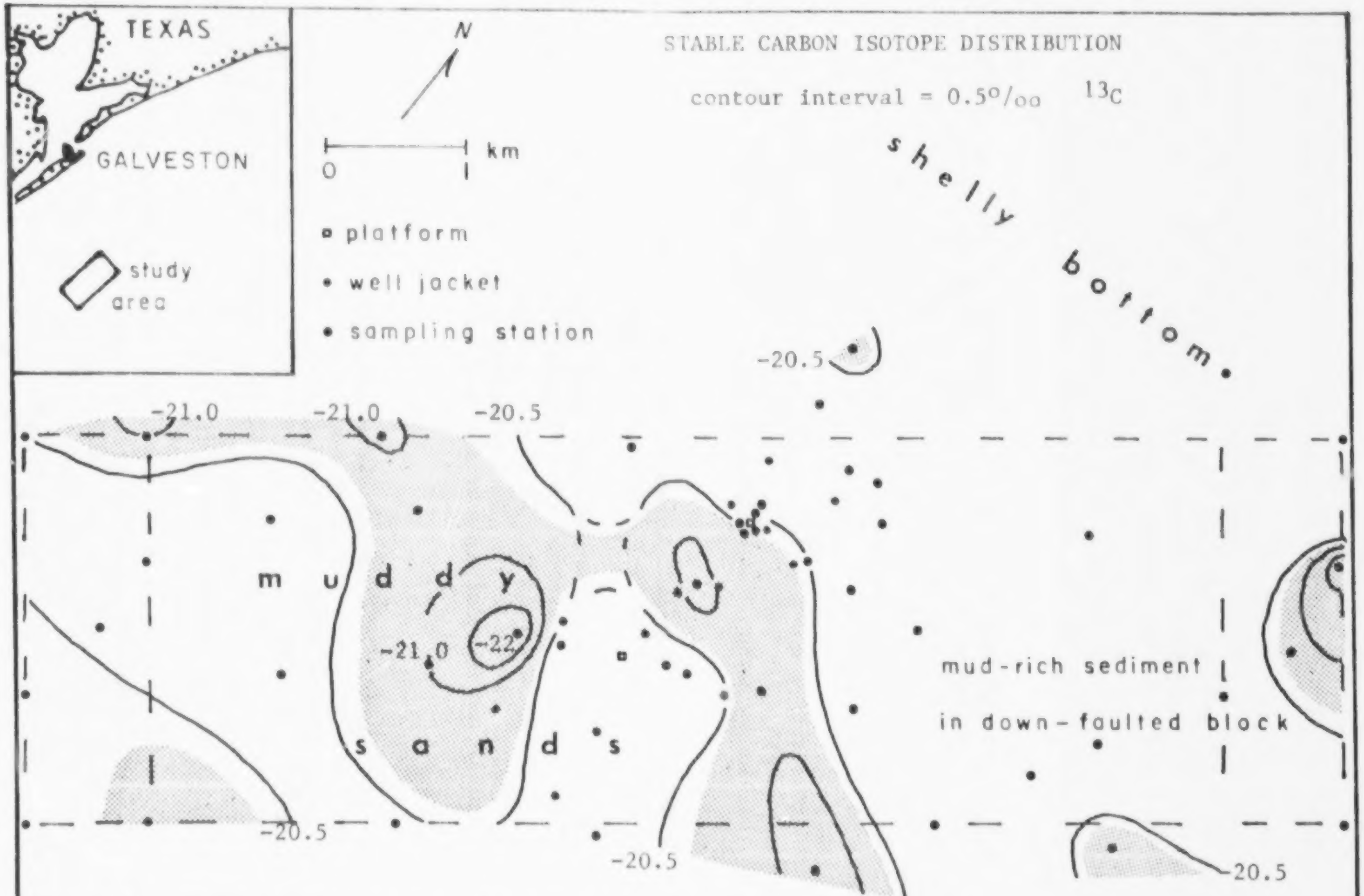

TEXAS
GALVESTON
study area
N
0 km
▫ platform
• well jacket
• sampling station
STABLE CARBON ISOTOPE DISTRIBUTION
contour interval = 0.5°/oo 13C
shelly bottom
-21.0
-21.0
-20.5
-20.5
muddy sands
-21.0
-22
-20.5
-20.5
mud-rich sediment in down-faulted block
-20.5

Figure 4. Stable carbon isotope distribution in surficial sediments (upper 2 cm). Shaded area shows distribution of the more negative frequency mode shown in Figure 2.

younger than it really is. If this had occurred, the uppermost part of the core would appear to have been deposited in less time than it really was and thus would appear to have a high rate of deposition relative to unaffected parts of the core. Actually, the youngest date gives a slower rate of deposition than the rest of the dates in the core. Furthermore, each successively deeper date gives a higher rate of sedimentation. This is generally true in the other cores dated and appears to be real and natural (Table 1).

A second basic component of the prediction model was that oil field activities would result in additional sedimentation or addition to the natural sedimentation taking place in the study area. The radiocarbon ages of surficial sediment indicate that not deposition, but erosion of the bottom has taken place within the field. From the cores closest to Platform A (50E) to the cores from the offshore control area the uppermost 4 or 5 cm of the cores examined have successively younger ages (Figure 5). Using the depositional rates from the control area these ages indicate that from the core 15 m from Platform A one meter of sediment has been eroded, from the core 152 m from Platform A 24 cm has been eroded, and from the core 1.8 km from Platform A 7 cm has been eroded.

Erosion of sediments affected by the field does not necessarily indicate that no polluting carbonaceous material has been added to the sediment, because quite temporary deposition of such material, or even suspension of it near the bottom might enable detritus feeding organisms to scavenge it and incorporate it into the sediments through their natural life processes (e.g., defecation, burrowing, and interment after death). The occurrence of two $\delta^{13}C$ modes with one distinctively more negative (-20.7) than the predicted shelf sediment value (-20.1) warrants further examination of the data for such a pollution effect.

The tails of the $\delta^{13}C$ frequency distribution curve are not particularly useful in this regard, because they can be related to other phenomena. The relatively negative Beaumont material, for example, probably contains predominantly terrestrial carbon which is normally more negative than marine carbon (a Texas coastal fresh water lake sediment has a $\delta^{13}C$ of -22.4 compared with the Beaumont's -22.7).

On the other hand, the tail of 19 samples more positive than -20.0 may reflect the occasional inclusion of fresh tissue of marine organisms in the sediment. The observed values would result from such inclusion, because live organisms are more positive than sedimented organic matter. An average value for 6 live shelf organisms is -18.1 (B. Fry, personal communication).

The Beaumont Formation is not considered a probable source for the carbon causing the more negative of the two large modes, because all but two of the 14 samples taken closest to the Beaumont contact in the cores have $\delta^{13}C$ values well within the more positive mode, and the average of all 14 samples

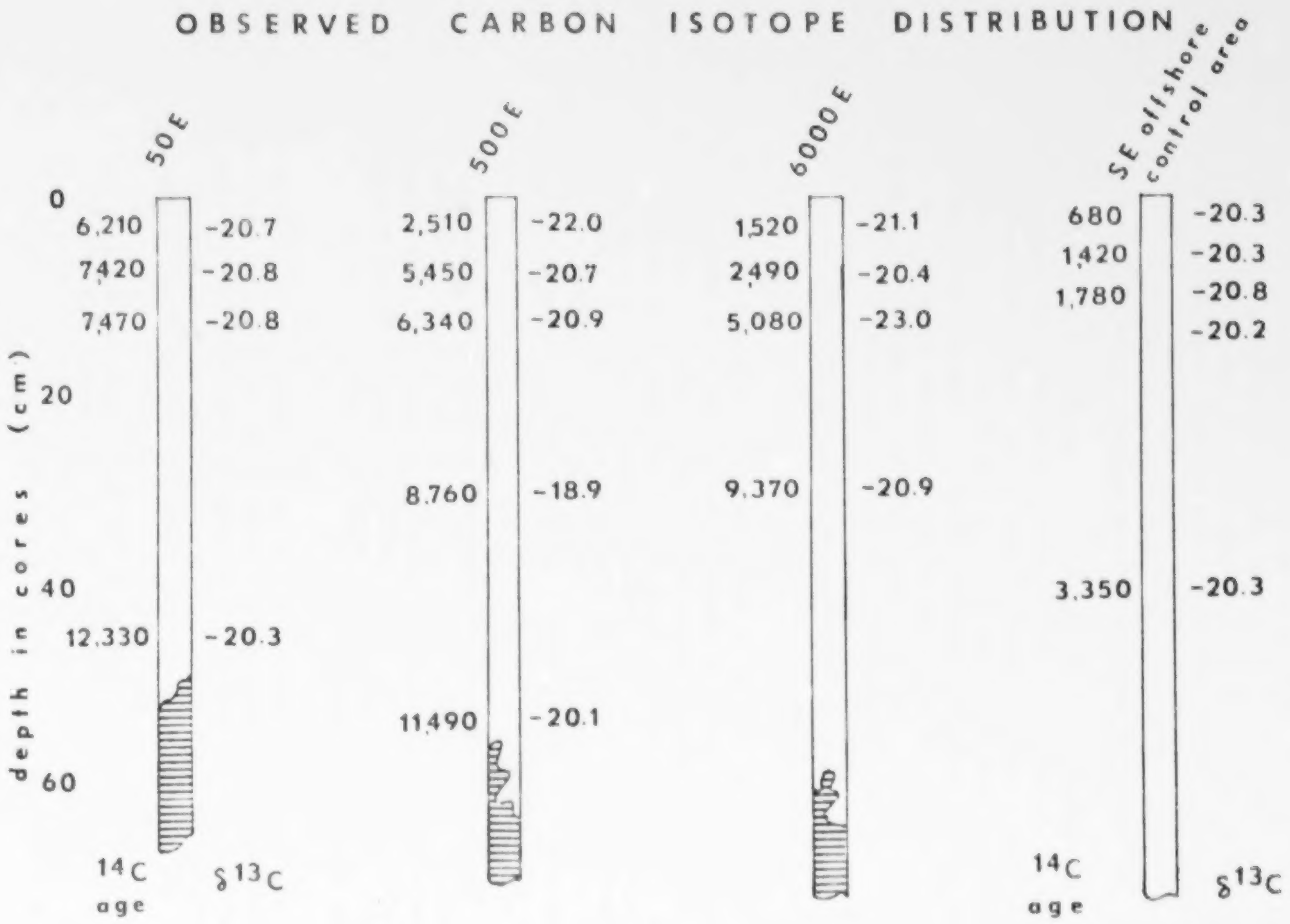


Figure 5. Observed carbon isotope distribution in cores. Lined parts are Pleistocene Beaumont Formation clays. Core designations ending in E indicate distance in feet East of Platform A. Control area is about 7 km Southeast of the field. Compare with Figure 1.

Table 1

Rates of Sedimentation calculated from Radiocarbon ages in cores

	Core 50 E			Core 500 E			Core 6000 E			SE Control	
Core Interval (cm)	Ages (B.P.)	Sed. Rate (cm/cent)	CI	Ages (B.P.)	S.R.	CI	Ages (B.P.)	S.R.	CI	Ages (B.P.)	S.R.
0-2.5	0-6,210	0.04	0-2.5	0-2,570	0.10	0-2.5	0-1,520	0.16	0-2.5	0-680	0.29
2.5-7.5	6,210-7,420	0.21	2.5-7.5	2,510-5,450	0.17	2.5-7.5	1,520-2,490	0.52	2.5-7.5	680-1,420	0.54
7.5-12.5	7,420-7,470	5.0	7.5-12.5	5,450-6,340	0.56	7.5-12.5	2,490-5,080	0.19	7.5-12.5	1,420-1,780	1.11
12.5-45	7,470-12,330	0.86	12.5-30	6,340-8,760	0.72	12.5-30	5,080-9,370	0.41	12.5-40	1,780-3,350	1.91
			30-55	8,760-11,490	0.92						

	Core 3000 N	
CI	Ages (B.P.)	S.R.
0-95	0-8,940	1.06
95-103	8,940-9,500	1.43

(-20.1) falls near the more positive limit of that mode (-20.0).

If oil field activities are, indeed, a source of isotopically more negative carbon that causes the more negative of the two major modes of $\delta^{13}C$ values, its addition to the sediment would tend to cause surficial sedimentation rates to seem small compared to rates in deeper, unaffected parts of cores. Furthermore, decreasing upward sedimentation rates should correlate with more negative $\delta^{13}C$ values. Rates do decrease upward in cores, but they do so in the control area as well as within the field. Also the lower sedimentation rates do correlate with $\delta^{13}C$ of the more negative mode within the field where 8 of the 9 values for the upper 15 cm of three cores are in that mode; but the decreasing upward rates also occur in the control area where 4 of the 5 $\delta^{13}C$ values for an equivalent interval are in the positive mode.

Some support for the pollution hypothesis exists in that apparent deposition rates decrease from the control area to within the field for most parts of the cores (Table 1). However, the time periods sampled by each set of dates are not the same; and there is no assurance that real rates did not vary through time to produce the variations observed.

A further examination of the distribution of $\delta^{13}C$ values as a function of distance from a major production platform (Platform A) includes almost 100 samples. These were taken at core depths of 0, 10, 20, and 50 cm. The summarized data (Table 2) show that only those stations within 15 m (50 feet) of the platform have an obvious predominance of negative mode values. The negative mode actually becomes more abundant away from the platform for the rest of the stations. Extending this to the control areas confuses the picture further, because while the southeastern (offshore) area is clearly predominantly in the positive mode, the southwestern area is predominantly in the negative mode.

Table 2 . $\delta^{13}C$ modes and values with distance from Platform A

Distance from Platform	Mean $\delta^{13}C$	% of Samples in Negative Mode
15 m	-20.9	61
53 m	-20.2	25
76 m	-20.4	33
152 m	-20.46	47
460 m	-20.49	56
1.8 km	-21.1	71
5 km (Y)	-20.9	82 (southwest)
5 km (offshore)	-20.4	20 (southeast)

DISCUSSION AND CONCLUSIONS

The most obvious effect of the oil field studied is the erosion of sediments within the field. Radiocarbon dating allows quantitative estimates of this erosion of from 7 cm to one meter. Observation of the depth of the Beaumont Formation in cores suggests that somewhat more erosion - up to 1¼ m - occurs locally. With erosion predominating over deposition, any carbonaceous pollutants would more likely accumulate outside of the field than within it. In this light, the data in Table 2 could be used to support a hypothesis of pollution.

The possibility that some pollutants have accumulated in the sediments is suggested by reduced rates of deposition as calculated from radiocarbon data. The bimodal distribution of $\delta^{13}C$ values could also result from addition of negative carbon from the field. However, neither type of data supports firm conclusions.

The more negative, possibly polluted $\delta^{13}C$ mode occurs abundantly at depth as well as in surficial sediments and is irregularly interspersed with the more positive mode. Thus it seems it could not have selectively invaded many older parts of the cores from a surficial pollution source. A possible mechanism does exist, however, in the activities of benthic in fauna.

The rates of sedimentation within the field are similar enough to those in the control area examined to conclude that they may not be affected by the addition of ^{14}C depleted carbon except, perhaps, very close to a major production platform. However, some suggestive differences do exist; and a possible effect in the control area cannot be eliminated.

The primary limitation of these conclusions is the lack of definition of control conditions. Rapid changes in sediment type near the field make control areas hard to define; and the control areas with sediments most like those within the field have conflicting stable carbon isotope characteristics. Furthermore, the possibility that pollution effects may be greater outside of the field than within it requires greater definition of the sedimentary environment over a broader portion of the continental shelf than just the oil field and immediately adjacent areas.

To remedy the deficiencies of this project a sedimentological study should extend several times the dimensions of the oil field. Extensive sampling should be done by piston coring; and the cores should be sampled continuously at close intervals. Carbon isotope data could be analysed further by mathematical testing of mixing models of natural and polluting sources. This should be supplemented by an isotopic survey of the common benthic organisms of the area.

Literature Cited

Gearing, P. J. (1975). Organic carbon stable isotope ratios of continental margin sediments. Ph.D. dissertation, The University of Texas at Austin, 154 pp.

Plucker, F. E. (1970). Stable carbon isotope ratios of organic matter of Gulf of Mexico shelf sediments. M. A. thesis, The University of Texas at Austin, 48 pp.

APPENDIX

Total Organic Carbon (TOC) and Carbon Isotope Data for Buccaneer Oil Field Study

footnotes:

1. Station labels beginning with an S were sampled by the Rice University Sedimentology study.

2. Sample mostly shell, TOC is for sediment after carbonate is removed.

3. Beaumont Formation

4. Station labels ending in N, E, S, or W designate distance of station in feet from Platform A.

5. Station labels beginning with C indicate piston cores; 49-52 - southeast control area; 53-56 - southwest control area; 57-60 - northwest control area; 61-64 - northeast control area.

6. Radiocarbon age based on shell material.

Sample Number	Station	Depth In Core (cm)	TOC %	$\delta 13_C$	$\delta 14_C$	Radiocarbon Age
1	S 6[1]	0-2	0.52	-20.1		
2	S 6	2-4	0.63	-20.2		
3	S 6	4-6	0.57	-19.8		
4	S11	0-2	0.38	-20.2		
5	S13	0-2	0.58	-20.2		
6	S17	0-2	0.31	-20.3		
7	S18	0-2	0.36	-20.3		
8	S21	0-2	0.20	-20.8		
9	S31	0-2	0.60	-20.4		
10	S32	0-2	0.28	-21.6		
11	S38	0-2	0.35	-20.1		
12	S39	0-2	0.29	-20.8		
13	S40	0-2	0.38	-20.2		
14	S61	0-2	0.30	-20.4		
15	S62	0-2	0.40	-20.2		
16	S63	0-2	0.29	-21.2		
17	S67	0-1	0.17	-21.7		
18	S67	1-2	0.29	-20.1		
19	S67	2-3	0.31	-20.5		
20	S67	3-4	0.50	-20.5		
21	S67	4-5	0.49	-20.7		
22	S67	5-10	0.39	-20.7		
23	S67	10-12	0.44	-20.7		
24	S69	0-2	0.41	-20.2		
25	S69	2-4	0.36	-20.5		
26	S69	8-10	0.24	-20.8		
27	S66	0-10	4.56	-17.5[2]		
28	S71	0-2	0.54	-20.2		
29	S71	14-16	0.51	-20.3		
30	S74	0-1	0.29	-20.5		
31	S74	1-2	0.27	-20.8		
32	S74	2-3	0.18	-20.5		
33	S74	3-4	0.29	-20.4		
34	S74	4-6	0.38	-20.4		
35	S74	6-8	0.31	-20.4		
36	S74	8-10	0.24	-20.7		
37	S74	10-12	0.33	-21.1		
38	S73	0-2	0.34	-21.0		
39	S76	0-1	0.34	-20.8		
40	S76	1-2	0.36	-20.4		
41	S76	2-3	0.45	-21.7		
42	S76	3-5	0.30	-20.5		
43	S76	5-10	0.34	-20.2		
44	S76	10-15	0.33	-20.3		
45	S76	15-18	0.27	-20.4		

Sample Number	Station	Depth In Core (cm)	TOC %	$\delta^{13}C$	$\delta^{14}C$	Radiocarbon Age
46	S77	0-2	0.15	-19.5		
47	S78	0-2	0.32	-21.0		
48	S78	2-11	0.33	-20.3		
49	S80	0-2	0.32	-20.2		
50	S81	0-2	0.33	-20.1		
51	S82	0-2	0.34	-20.3		
52	S83	0-2	0.25	-21.0		
53	S84	0-2	0.45	-20.7		
54	S84	2-7	0.36	-20.1		
55	S85	0-2	0.30	-20.3		
56	S86	0-2	0.30	-20.4		
57	S87	0-2	0.28	-20.0		
58	S89	0-2	0.21	-21.1		
59	S92	0-2	0.10	-19.6		
60	S94	0-2	0.36	-20.3		
61	S96	0-2	0.42	-20.5		
62	S96	2-5	0.41	-20.4		
63	S96	5-8	0.34	-21.9		
64	S97	0-2	0.39	-20.4		
65	S98	0-2	0.21	-21.1		
66	S99	0-2	0.23	-20.9		
67	S100	0-2	0.39	-20.3		
68	S102	0-2	0.18	-20.1		
69	S102	4-5	0.96	-14.1		
70	S102	9-10	0.77	-13.7		
71	S103	0-10	4.97	-17.8[2]		
72	S104	0-2	0.52	-20.1		
73	S105	0-2	0.48	-20.3		
74	S107	0-2	0.26	-20.3		
75	S110	0-2	0.37	-21.5		
76	50W[4]	0-2	0.31	-20.5		
77	50W	9-11	0.32	-22.8		
78	50W	19-22	0.26	-20.6		
79	50W	42-43	0.21	-22.3[3]		
80	50W	77-80	0.62	-23.1[3]		
81	50W	82-84	0.39	-22.7[3]		
82	250W	0-2	0.18	-20.4		
83	250W	10-12	0.11	-20.4		
84	250W	31-34	0.25	-20.1		
85	250W	55-58	0.16	-22.5[3]		
86	250W	68-80	0.25	-20.6		
87	250W	77-81	0.57	-23.1[3]		
88	250W	85-90	0.70	-23.0[3]		
89	50E	70-80	0.74	-22.5[3]	-936	22,120 ± 1440
90	250E	95-105	0.66	-22.7[3]	-954	24,810 ± 1170

Sample Number	Station	Depth In Core (cm)	TOC %	$\delta^{13}C$	$\delta^{14}C$	Radiocarbon Age
91	50E	0-5	0.21	-20.7	-539	6,210 ± 650
92	50E	5-10	0.20	-20.8	-602	7,420 ± 670
93	50E	10-15	0.20	-20.8	-605	7,470 ± 430
94	50E	40-50	0.26	-20.3	-784	12,330 ± 4080
95	500E	0-5	0.17	-22.0	-268	2,510 ± 170
96	500E	5-10	0.22	-20.7	-492	5,450 ± 290
97	500E	10-15	0.20	-20.9	-546	6,340 ± 220
98	500E	28-32	0.18	-18.9	-664	8,760 ± 710
99	500E	50-60	0.27	-20.1	-761	11,490 ± 8035
100	6000E	0-5	0.30	-21.1	-172	1,520 ± 280
101	6000E	5-10	0.29	-20.4	-266	2,490 ± 160
102	6000E	10-15	0.24	-23.0	-469	5,080 ± 520
103	6000E	27-33	0.25	-20.9	-688	9,370 ± 600
104	C49-52[5]	0-4	0.19	-20.3	- 81	680 ± 240
105	C49-52	4-8	0.16	-20.3	-162	1,420 ± 220
106	C49-52	8-12	0.19	-20.8	-198	1,780 ± 300
107	C49-52	12-16	0.16	-20.2	-233	2,140 ± 130[6]
108	C49-52	37-43	0.25	-20.3	-342	3,350 ± 350
109	C61-64	8-12	0.47	-20.7	-384	3,890 ± 150
110	C61-64	23-27	0.49	-20.3	-762	11,540 ± 460
111	C61-64	48-52	0.66	-21.2	-741	10,860 ± 380
112	C61-64	73-77	0.48	-19.4	-750	11,120 ± 440
113	C58	0-1			-410	4,240 ± 100[6]
114	C58	15-17			-436	4,610 ± 70[6]
115	C57	33-35	0.26	-21.0	-402	4,130 ± 100
116	C57-60	48-52	0.21	-22.3	-389	3,850 ± 440
117	3000N	99-107	0.23	-20.0	-693	9,500 ± 740
118	3000N	91-99	0.24	-20.1	-671	8,940 ± 510
119	50E	1-12	0.32	-19.4	-610	7,550 ± 370
120	175W	0-1	0.15	-21.3		
121	175W	9-11	0.20	-20.6		
122	175W	19-21	0.24	-21.5		
123	175W	49-51	0.28	-19.4		
124	500W	0-1	0.21	-20.3		
125	500W	9-11	0.23	-20.5		
126	500W	19-21	0.14	-20.8		
127	500W	49-51	0.21	-20.3		
128	50N	0-1	0.21	-20.7		
129	50N	9-11	0.20	-20.6		
130	50N	19-21	0.09	-20.2		
131	175N	0-1	0.16	-20.4		
132	175N	9-11	0.29	-19.5		
133	175N	19-21	0.28	-19.8		
134	250N	0-1	0.16	-21.1		
135	250N	9-11	0.20	-20.3		

Sample Number	Station	Depth In Core (cm)	TOC %	$\delta^{13}C$	$\delta^{14}C$	Radiocarbon Age
136	250N	19-21	0.21	-20.5		
137	250N	49-51	0.15	-20.2		
138	500N	0-1	0.26	-20.5		
139	500N	9-11	0.31	-20.3		
140	500N	19-21	0.16	-20.7		
141	500N	49-51	0.21	-19.5		
142	50S	0-1	0.42	-21.4		
143	50S	9-11	0.28	-20.0		
144	50S	19-21	0.32	-21.7		
145	175S	0-1	0.25	-19.7		
146	175S	9-11	0.25	-18.9		
147	175S	19-21	0.18	-20.2		
148	250S	0-1	0.21	-20.9		
149	250S	9-11	0.41	-19.6		
150	250S	19-21	0.62	-18.8		
151	500S	0-1	0.18	-20.1		
152	500S	9-11	0.17	-20.8		
153	500S	19-21	0.20	-20.8		
154	500S	49-51	0.20	-20.9		
155	175E	0-1	0.11	-20.2		
156	175E	9-11	0.19	-20.7		
157	175E	19-21	0.23	-20.4		
158	175E	49-51	0.19	-19.6		
159	250E	0-1	0.23	-20.7		
160	250E	9-11	0.18	-21.0		
161	250E	19-21	0.26	-20.6		
162	250E	49-51	0.19	-20.5		
163	C 61	0-10	0.41	-20.8		
164	C 61	0-10	0.44	-21.0		
165	C 61	0-10	0.42	-21.1		
166	C 61	0-10	0.45	-20.6		
167	C 62	0-10	0.41	-20.7		
168	C 62	0-10	0.39	-20.7		
169	C 62	0-10	0.42	-20.7		
170	C 62	0-10	0.38	-20.8		
171	C 63	0-10	0.44	-20.7		
172	C 63	0-10	0.46	-20.8		
173	C 63	0-10	0.45	-20.9		
174	C 63	0-10	0.54	-21.1		
175	C 64	0-10	0.44	-20.7		
176	C 64	0-10	0.42	-20.7		
177	C 64	0-10	0.42	-20.7		
178	C 64	0-10	0.44	-20.5		
179	C 56	0-4	0.23	-20.4		
180	C 56	4-8	0.30	-20.5		

Sample Number	Station	Depth In Core (cm)	TOC %	$\delta^{13}C$	$\delta^{14}C$	Radiocarbon Age
181	C 56	8-12	0.31	-20.6		
182	C 56	12-16	0.30	-20.7		
183	C 56	16-20	0.29	-20.9		
184	C 56	20-24	0.28	-21.1		
185	C 56	24-28	0.24	-21.2		
186	C 56	28-32	0.20	-21.2		
187	C 56	32-36	0.25	-21.1		
188	C 56	36-40				
189	C 56	40-44	0.23	-20.8		
190	C 56	44-48	0.27	-20.6		
191	C 56	48-52	0.26	-20.7		
192	C 56	52-56	0.45	-20.7		
193	C 56	56-60	0.26	-21.6		
194	C 56	30-40	0.25	-21.3		
195	C 67	0-1	0.32	-20.1		
196	C 67	9-11	0.24	-20.9		
197	C 67	19-21	0.16	-20.6		
198	C 67	49-51	0.25	-19.4		
199	C 68	0-1	0.34	-20.3		
200	C 68	9-11	0.22	-20.8		
201	C 68	19-21	0.19	-20.8		
202	C 68	49-51	0.20	-21.0		
203	C 70	0-1	0.30	-20.7		
204	C 70	9-11	0.30	-20.9		
205	C 70	19-21	0.18	-20.7		
206	C 70	49-51	0.20	-21.0		
207	C 72	0-1	0.24	-20.3		
208	C 72	9-11	0.22	-21.0		
209	C 72	19-21	0.19	-21.0		
210	C 61	10-20				
211	C 61	10-20				
212	C 61	10-20	0.48	-21.0		
213	C 61	20-30				
214	C 61	20-30	0.53	-20.9		
215	C 61	20-30	0.20	-20.2		
216	C 61	20-30	0.38	-20.3		
217	C 61	30-40	0.49	-20.4		
218	C 61	30-40				
219	C 61	30-40				
220	C 61	30-40				
221	C 61	40-50				
222	C 61	40-50	0.48	-20.0		
223	C 61	40-50				
224	C 61	40-50				
225	C 61	50-60	0.68	-20.6		

Sample Number	Station	Depth In Core (cm)	TOC %	$\delta^{13}C$	$\delta^{14}C$	Radiocarbon Age
226	C 61	50-60	0.68	-20.3		
227	C 61	50-60	0.69	-20.6		
228	C 61	50-60				
229	C 61	60-70				
230	C 61	60-70	0.68	-20.9		
231	C 61	60-70	0.73	-20.9		
232	C 61	60-70	0.73	-20.8		
233	C 61	70-80	0.76	-19.3		
234	C 61	70-80				
235	C 61	70-80	0.77	-19.6		
236	C 61	70-80	0.69	-19.1		
95	500E	0-5	0.17	-22.0	-393	4,000 ± 120[6]
96	500E	5-10	0.22	-20.7	-443	4,700 ± 180[6]
116	C57-60	48-52	0.21	-22.3	-369	3,690 ± 200[6]
237	C57	14-16			-427	4,460 ± 70[6]
102	6000E	10-15			-426	4,460 ± 230[6]
105	C49-52	4-8			-144	1,250 ± 170[6]
113	C 58	0-1			-433	4,560 ± 70[6]
108	C49-52	37-43			-242	2,230 ± 170[6]